A Semimonthly Technical Newspaper

Metallurgical & Chemical Engineering

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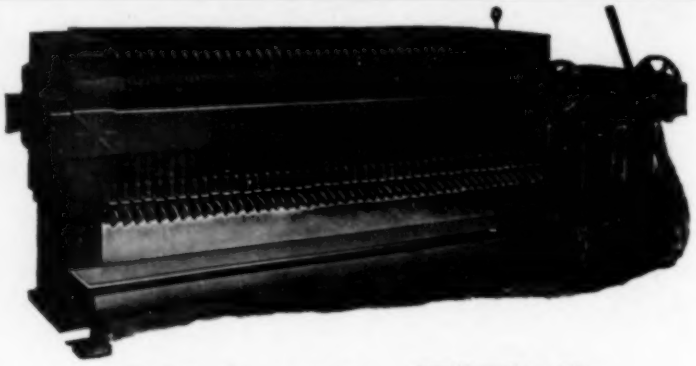

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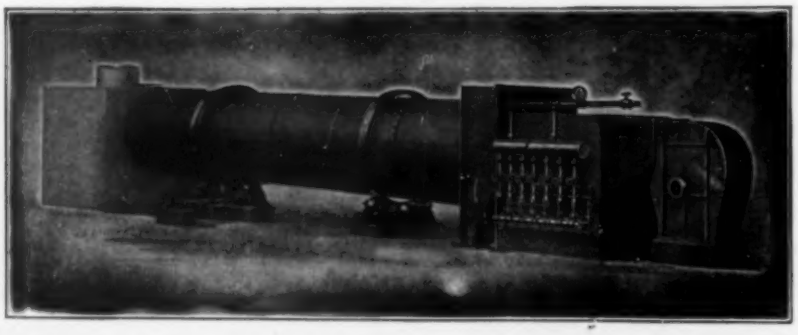

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A Legislative Solution of the Niagara Problem

FROM a bill introduced in the Senate of the State of New York by Mr. Gibbs on Jan. 15, 1918, we extract the following:

> "The sum of three million dollars ($3,000,000), or so much thereof as may be necessary, is hereby appropriated, payable out of the moneys realized under the sale of bonds as provided by section one of this act, to be expended by the commissioners of the state reservation at Niagara for the preparation of plans, specifications and estimates and the construction and equipment of a hydro-electric power plant, to be constructed under their supervision and control on land belonging to the state on the state reservation at Niagara, which plant when completed and equipped shall develop not less than five hundred thousand horsepower."

This indicates a capital cost of not more than $6 per horsepower developed! An engineer might doubt his ability to do so much within the limits of the appropriation; but provision is made, with great foresight, for the limitations of mere engineering ability:

> "The legislature shall prescribe the method and manner by which such commissioners shall obtain the necessary plans and specifications and estimates and prescribe their powers and duties in connection with the construction and operation of such plant."

An excellent example of the Bolshevik principle that any feat can be achieved by legislative action.

Meanwhile some Senator might with advantage introduce the following amendment:

> "The sum of thirty cents (30c.), or so much thereof as may be necessary, is hereby appropriated, to be expended for the elementary education of Mr. Gibbs in the subject of the cost of hydro-electric development."

The War Department Discovers the Chemist

FROM the time the United States entered the war to the present day there have been a few people who realized the importance of the chemist in the general scheme of industrial affairs. And when it was proposed to take him from his tasks and make a soldier of him, there were a few voices raised in opposition.

Comes now the Adjutant General of the Army, however, with official recognition of the importance of the chemist in industry. Through an order of the Adjutant General provision has been made whereby manufacturers of essential war materials who have lost chemists through the first draft may again obtain the services of these men, and those now threatened with the loss of chemists through the present draft may retain them. The request for exemption must come from the manufacturers; applications from the men will not be considered. Manufacturers thus affected should apply to the Chemical Service Section, N. A., New Interior Building, Washington, D. C., for the regulations governing the transfer of men already drafted or the possible reclassification of men not yet called.

The Need of Co-ordination at Washington

CONSIDER the United States as being in business, for war is business on so vast a scale as to transcend any other enterprise with which it might be compared. The particular feature of this business is production; munitions and supplies must be made and taken to armies in the field. It has been said that this is a war of production and transportation. Another feature of this business is that it is incidental to our political life and is not the normal pursuit of our political officers. Being incidental, it is conceivable that it may not be run efficiently by men selected for reasons wholly foreign to the making of war, and consequently unfamiliar with its *modus operandi*. A logical antidote for this inevitable inefficiency is to model the nation's business of the moment along the lines of private industry.

Now private industry has been the subject of searching analysis in recent years, with the result that problems of production have been pretty well solved and standardized. The production engineer has been having his innings in business, and he has made some effective hits. One of the conditions which he regards as fundamental in a manufacturing business is complete co-ordination of the work of the several departments that contribute to the finished product. The principle is axiomatic. It were unwise for an automobile maker, for instance, to allow the production of wheels, brakes, engines and bodies to proceed promiscuously, lest his unsystematic methods bring him to grief. Or, in more homely vein, he were a poor chef who would so direct the preparation of a dinner that the dessert spoiled before the soup was prepared.

In simple affairs, co-ordination may be accomplished by an orderly mind; but for complex industrial problems, production charts are resorted to by engineers in order to visualize production and enable the responsible head to co-ordinate the different branches of the work.

With this background we may now consider a fundamental trouble at Washington and prescribe the remedy. There has been a lack of co-ordination in the production program. Each officer or official responsible for a particular item has made a blind drive for production without regard to the relation of his part to the whole. Production charts are an unknown quantity in some of the offices, and there is no centralized authority responsible for the entire production program. There is no one to order a lag here or acceleration there in order to prevent congestion at some points and famine at others. Finally, production has not been co-ordinated with transportation, and the resulting jam is a matter of recent history. The fuel order, in the last analysis, was a public confession of lack of co-ordination at Washington.

The remedy lies in immediately charting the work of all the procurement divisions and co-ordinating the entire production and transportation program by the appointment of a responsible head. The charting is more important and should be done first, because charts will confound and expose an incompetent director, whereas they would be the first requisite of an able man. Failing the immediate accomplishment of these things, we will have fresh disasters to face in the course of a few months or even weeks.

Misdirecting Directors

IN HIS address before the St. Louis meeting of the American Institute of Chemical Engineers, which we print elsewhere, Mr. Frank Hemingway made some observations in regard to companies engaged in chemical industry which we think important. "I know of many companies of large size," he said, "whose boards of directors are composed wholly of financiers and business men possessing no chemical knowledge whatsoever, and in which there is no co-ordination between the directing head, the chemists and engineers or chemical engineers, the sales department and the purchasing department." This is not a surprising declaration; it is even a familiar situation in American industry, chemical or otherwise, and it is a fault of which banks and financial institutions have not yet taken adequate notice. It is a legacy of High Finance developed in the palmy days of trust flotation, and we are still suffering from it. The Board of Directors was made a kind of a show-window of corporations for stock-selling purposes. It was held that with a handsome array of money-makers on the directorate any new company would be sure to earn fat dividends. We know better, but we do not believe better, because this notion has become a tradition.

The board of directors of a manufacturing concern is charged with grave responsibilities. It bears the obligations of the welfare of the corporation, of the joint and not the separate fortunes of the stockholders, and it has to do with the relations of the corporation to industry, to its employees, to the community and to society. It is not merely a finance committee. Generally speaking, the better and more competent the whole board, the less work is there for the finance committee to do. This concept of the situation is so frequently lost sight of as to constitute a grave menace to national industry. The finance committee has to do with the disposition of earnings and with borrowing money to be spent by the corporation; but what is the use in borrowing money if you do not know how to use it? Such a board as Mr. Hemingway described does not know how to use it.

The manufacturing, selling, purchasing and research departments of an industrial concern constitute its heart. If a director of an organization is not familiar with these features and with their relations to each other, his presence as a member of the board is an act of culpable neglect. No matter how rich or successful he may be, he is useless as a director until he knows what is going on within the establishment.

Our ideas of the functions of a board of directors are so loose that offenses against industry by inadequate or defective personnel are of frequent occurrence and no heed is paid to the fact. Occasionally a swashbuckling speculator bulldozes his way into membership by means of another traditional fiction that any considerable ownership of stock entitles the holder to personal representation in the body no matter how ignorant or incompetent he may be to guide the delicate and complex mechanism of affairs that the corporation has in hand. The stigmata of such a man are likely to show in the annual report. "Unnecessary charges have been eliminated," we learn, and on investigation discover that the new director has begun to cut out deadwood, which is his favorite occupation. This consists in discharging

men who have served the company for many years and who may have needed bracing but, likely as not, were faithful and needful to the organization. Affluent traders of this type are likely to hate research as smacking of theorism, which is anathema to their souls, and by the time such a man has been mixed up in the affairs of a manufacturing concern for a year, he has cut and slashed and broken the spirits of the men who remain until the whole organization is crippled—sometimes beyond repair. Generally speaking, it is a hazardous thing to tie up to an unsuccessful man, but the successful man, ignorant of the details of an industry and whose mind is closed by vanity, is a greater danger.

American industry is in a good deal of a jumble. It needs guidance. Its difficulties are rather with theory than with finance. We do not claim that a board of directors of a manufacturing corporation should consist of department heads of the company. That would involve letting the concern run itself, while it is right and proper that the directors should be representative of the stockholders and not alone of the president. But these men are useless unless they understand the business well enough to know its actual needs. Directors should be retained by stockholders for the work they can do and for their good counsel. Their business is to conserve the welfare of the whole corporation and this requires knowledge and understanding of the business in hand as well as acumen in other affairs. They should not be selected to conserve special interests or because they have made fortunes in some entirely unrelated walk of life. It is time to take annual stockholders' meetings more seriously and to shake up the proxy committees. A sense of this need may be obtained by the comparison of the live, efficient and capable boards of a number of the great American industrial corporations with the complacent body of merchants and bankers that sit in idleness and vanity on the boards of a vast number of concerns even now engaged in the struggles of birth.

Better Work Needed

THE loss of the Tuscania with American troops aboard, of whom happily but few were lost, brings to us a fuller realization of how fortunate it is that the submarine menace has been largely reduced in the past few months. But the curtailing of destruction by submarines cannot lessen our chagrin that our shipbuilding has proceeded so slowly. While it is only ten months since our formal declaration of war, it is a full year and more since the necessity of our building ships as rapidly as possible was made clearly apparent. In retrospect we seem to have done very little indeed. Possibly it is harsh to judge us by our own expectations, but if that is to be the standard we certainly are condemned. We were to start a perfect procession of wooden boats, almost a pontoon, tandem fashion, by Oct. 1, 1917. It took us months to realize the chimerical nature of that project.

We have a hard and immeasurably important task before us, and it should do us good to think for a moment of the mistakes, the egregious blunders we have made, particularly since the chances for blundering are not all past. Like the poor, we have them with us always. The wooden ship idea was embraced because, forsooth, we had no plates! What is the condition to-day? The plate mills are unable to operate at capacity because of the breakdown in transportation, but if they were they would be able to flood the country with plates. In 1916 we produced a trifle more than 1,800,000 gross tons of sheared plates, quarter-inch and heavier. To-day we can produce very nearly twice that tonnage. If we were able to build steel ships at the rate of 500,000 deadweight tons a month, which we are very far from being able to do, we could supply all the plates required, meet all possible export demands, and still have a large surplus. Twelve months ago we were thinking of wooden ships as the only thing possible, but those easily possible, and nine months ago General Goethals' announcement that he was turning to steel ships, and had been promised the steel plates, started a controversy which it is unpleasant, but perhaps profitable, to keep in recollection.

It is difficult to correlate what we see. Everybody has a job and presumably everybody is working at it. Fuel Administrator Garfield stated in connection with his plant-closing order that production had outrun requirements, hence a little holiday could do no material harm. What is the work that is being done? The people have certainly decreased their consumption. There is very little building, except in connection with war work. Altogether, if we are really at work we should be producing more, along right lines, than we are. More production, with less consumption in ordinary peace activities, are the two material desiderata. Apparently we have them both, in very large measure, but the sum of the two items, which represents the war activity, should be large, very large, and yet it does not seem to be so.

It is clear, at any rate, that ordinary commercial activity has greatly decreased. "Business as usual" has been killed as a slogan, and very properly. Forces, ability to do things to help win the war, are released, but it does not seem that they are fully and intelligently employed.

Much regret has been expressed of late that things should come to light of a nature calculated to dampen our enthusiasm in "winning the war." That is not the philosophy of winning wars, however. As was said of discovering the North Pole, "It's dogged as does it." It is not national psychology that excitement and enthusiasm increase as war is carried on. That comes early. What wins is the dogged determination, directed by intelligence.

Two things in particular are requisite. There must be a better system at Washington as regards the placing and following up of orders, and there must be a restoration of rail transportation facilities. The reform at Washington is in progress. Matters have been brought to the light. The confusion and argument may be unpleasant, but it will bring results.

As to the railroads, our enemy was an unprecedentedly hard Winter, our ally will be Spring. Transportation conditions have been so bad, crippling sadly nearly all industries, that it has been easy to forget that before winter came, and that not so long ago, the railroads were handling a volume of traffic far in excess of anything ever before attained. Railroad facilities were inadequate, but they were doing much better than could have been expected in the circumstances. They will do still better in future. Spring will bring new life, and the epidemic of spring fever will be the lightest in a generation, thanks to Mr. Hoover!

Readers' Views and Comments

Advantages of Hydro-Electric Power

To the Editor of Metallurgical & Chemical Engineering

SIR:—All the large industrial plants at Sault Ste. Marie are running as usual under special exemption by Dr. Garfield and W. K. Prudden from their recent and drastic fuel orders. These plants are operated by electricity produced by water power from the rapids of the St. Mary's River. The Michigan Northern Power Company and Edison Sault Electric Company produce and distribute about 40,000 hp. from these rapids. This power is used to operate all industries of any size at the Sault, including the immense plants of the Northwestern Leather Company, Union Carbide Company and Soo Woolen Mills. There is now immediately available at the Sault about 1500 hp. which can be increased to 4500 upon very short notice and the installation of the type of machinery most efficient for the operation of any particular industry.

Under the present fuel conditions this available water power is of great economic advantage to manufacturers who are or may be embarrassed for lack of fuel, the supply of which is restricted to those industries which the government may designate as essential.

We know that this item will be of interest to your readers and will naturally be pleased to have it brought to their attention.

SAULT STE. MARIE CIVIC
Sault Ste. Marie, Mich. AND COMMERCIAL ASSOCIATION.

Chemistry and the War

To the Editor of Metallurgical & Chemical Engineering

SIR:—It has been said that the present conflict is a war of chemists, and, to a very great extent, this is undoubtedly true. Never has artillery fire played so important a part in warfare.

The enormous tonnage of explosives required must by produced by the chemist. The chemist must produce also the materials for bombing and gassing, and he must furnish the fuels for ambulances, supply autos and aeroplanes. He must make the gun cotton for the war-head of the torpedo, and the high explosive for the depth bomb, the cement for concrete defenses and the gas masks for protection against the poisonous gas which the enemy chemist has produced. He manufactures many of the oils and concentrated foods used, and supplies the potash, nitrogen and phosphorus compounds used in the fertilizer necessary for the proper production of food stuffs. The khaki color which makes the soldiers' clothing inconspicuous in the field are also the product of his handiwork. He manufactures the numerous pharmaceutical products used in the hospitals and the sterilizing agents for the field water supplies.

The war has given a great impetus to the manufacture in this country of photographic developers, lenses, pharmaceuticals, synthetic perfumes, flavoring extracts, saccharin and numerous other products. Before the war, Germany and Austria supplied the world with the better grades of chemical apparatus and reagents. The United States bought many millions of dollars' worth annually of laboratory glassware. Since these importations automatically ceased we have been able to make our own glassware, which is now of a quality superior to that manufactured in Germany or Austria. We are also making an excellent quality of porcelain.

Before 1914 every pound of synthetic phenol came from Europe. Now a score or more plants are producing it in large quantities, chiefly for use in the manufacture of picric acid for war purposes. The September *Chemical Engineer* stated that the Edison works at Orange, N. J., is furnishing regularly 3,000,000 pounds of phenol per month.

At the beginning of the war, potash salts, for instance pearl ash, was selling at less than three cents a pound, and shortly after the price rose to $1.50 a pound, or more. Industrial establishments were obliged to use substitutes for all potash compounds or go out of business. Germany produced practically all of the potash at that time. To-day many methods are employed in this country to produce potash, some of which may well compete with the German products after the war.

Before the war, Germany made most of our colors used in textiles, leather, straw, feathers, paper, ink, pigments, varnishes, and for innumerable other products of our manufacture. At the present time we are ourselves manufacturing a quantity of color compounds equal to that used by us in normal times, and the number of colors produced is constantly increasing. Many concerns now manufacturing dyestuff intermediates have their own nitric acid, oleum, nitration, sulphonation, and acid-recovery plants.

With proper legislation we can manufacture on a competitive basis practically every chemical product which we now import. Cheap labor is not a factor of importance. The final selling price of the strictly chemical products imported into the United States annually before the war has been estimated by Gudeman (*Journal of Industrial and Engineering Chemistry*, February, 1915) at $250,000,000, of which not over four per cent represents labor value.

The tremendous advantage which Germany had at the beginning of the war has taken more than three years to counteract, and the result has been an awakening in other countries to the necessity of furthering the chemical and metallurgical industries in every possible way.

The Germans have for many years realized the grave necessity of furthering the work of the chemist and the chemical engineer for warfare, as well as for the necessities of industry in time of peace. They knew that by developing their enormous color establishments in peace times, they were producing factories which could be readily changed over to explosive works in time of war. They realized that the industries for the fixation of nitrogen used in fertilizers in time of peace could also be used for the production of enormous quantities of picric acid and trinitrotoluene in war time. They realized the necessity for acetone, synthetic phenol, industrial alcohol and all the numerous solvents and compounds used in peace as a still greater necessity for war.

The fact that strong corporations are entering the chemical manufacturing fields, indicates that capital

expects and feels a reasonable assurance that this country will properly further and sufficiently protect their interests after the war, in order that we may independently produce our own necessities and at the same time add new assets to the nation's wealth.

D. D. JACKSON.

Chemical Engineering Dept., Columbia University, New York City.

Precise Use of Figures

To the Editor of Metallurgical & Chemical Engineering

SIR:—I take the liberty of calling your attention to the extremely incorrect use of figures in the conversion table of Mr. Dwight Gerber in your issue of Jan. 15. In the example given, 5.5 lb. would be correctly expressed as 2490 g. But 5.5 lb. is different from 5.500 lb., for in the latter case the number of pounds is known to one-thousandth of a pound, while in the former case it is known only to the nearest tenth. This consideration shows the absurdity of converting 5.5 lb. to 2494.75835235 g. If 5.50000000000 lb. were converted to the number of grams given in the example there would be no criticism, but it is not very often that anything is weighed to this degree of accuracy.

M. DEKAY THOMPSON.

Cambridge, Mass.

Nickel-Chromium Wire

To the Editor of Metallurgical & Chemical Engineering

SIR:—The opinon seems to prevail to a certain extent, that the purchaser of an electric furnace employing nickel-chromium wire as its heating unit cannot secure a new unit with which to repair it when the wire burns out. We want to correct this erroneous impression.

It should be clearly understood that any concern or individual can buy units, in the form of coiled wire, having measured and definite resistance, with which to rewind any electric furnace built by a manufacturer licensed under the Marsh Patents. The user can purchase wire in this form and make the repairs himself.

These coiled units can be secured from the device manufacturer by giving him proper data, relative to the furnace to be repaired, such as Serial No., Type, Voltage, etc.

LICENSORS UNDER THE NICKEL-CHROMIUM RESISTANCE ELEMENTS PATENTS.

Laboratory Methods for Benzol-Recovery Plant Operation

To the Editor of Metallurgical & Chemical Engineering

SIR:—The following corrections and additions should be made to my article on the above subject published in your issues of Nov. 1, Nov. 15 and Dec. 1, 1917:

Method for the Determination of Light Oil in Gas.

Vol. 17, *No.* 9, *Nov.* 1, 1917, *pages* 550-551.

1. It is important that a complete blank test be run on the wash oil used. If the blank is high the oil should be thoroughly steamed out at a temperature of 160 deg. C. before using.

2. For passing gas through absorption apparatus, the rate of flow of the gas during the absorption should not exceed 2 cu. ft. per hour for benzolized gas, or 4 cu. ft. per hour for debenzolized gas.

3. In making steam distillation of oil from absorption apparatus, the temperatures given are in error. The oil should be heated until the temperature shows a temperature of 160 deg. C., and the temperature should be maintained between 150 deg. and 160 deg. C. throughout the steam distillation.

4. When testing unpurified water gas or other gas high in carbon dioxide, a tower of oxide and shavings is substituted for sodium hydroxide bottle in absorption apparatus (bottle No. 1, Fig. 1, p. 550).

The Analysis of Light Oil.

Vol. 17, *No.* 9, *Nov.* 1, 1917, *pp.* 551-555.

In Tables I and II, p. 553, under "Estimated by Method"—column headed "Benz. Lb." is in error and should read "Benz. %."

Method for the Boiling Point Tests of Benzols.

Vol. 17, *No.* 10, *Nov.* 15, 1917, *pages* 586-588.

The word internal was omitted in stating dimensions of diameter of vapor tube, so the third sentence in section headed "Flask" should read: "Half way up the side of the neck a vapor tube of not less than 5 mm. *internal* diameter," etc.

Sulphuric Acid Color Test for Benzol, Toluol, Solvent Naphtha, Etc.

Vol. 17, *No.* 11, *Dec.* 1, 1917, *page* 642.

The proportions of sulphuric acid and material to be tested are in error, and second sentence in second paragraph should read as follows:

"Sufficient concentrated (1.84 sp. gr.) sulphuric acid is put in to fill one-quarter of the bottle, and then twice as much of the material to be tested is added." The subsequent shaking and comparison are as stated.

Determination of Naphthalene in Oils.

Vol. 17, *No.* 11, *Dec.* 1, 1917, *pages* 646-647.

In making the determination of the free picric acid present, the quantity of benzol solution to be drawn from burette (page 647) is in error, and should be 1200

T

F. W. SPERR, JR.

H. Koppers Co., Pittsburgh, Pa.

Causticizing Soda Liquors

To the Editor of Metallurgical & Chemical Engineering

SIR:—I am surprised to note the absence of comment on one or two slight mis-statements appearing in the article "Causticizing Soda Liquors" in your issue of November 15, 1917. The authors state that the Dorr devices were developed principally for use in the concentration of ore in which the carrying fluid has no value. They intimate that this is a detrimental feature in the use of the apparatus in the causticizing process. While it is true that the flotation process for ores has given the Dorr apparatus great prominence in the field of ore concentration, we must remember that the early development, and for many years the only development, of Dorr apparatus was in connection with the cyanide process in which the carrying fluid (gold-cyanide solution) is the valuable portion and the pulp is wasted. Here we have exactly the same condition as is found in causticizing plants. To those who have worked with filters and who have vainly attempted to produce "a small volume of weak wash liquor" it seems strange to find the filtration process so strongly advocated at the expense of a more simple and efficient procedure.

IVAN E. GOODNER.

Paradise, Calif.

Western Metallurgical Field

Selective Flotation at Eureka, Colo.

THE United States Smelting, Refining & Mining Company have purchased the Gold Prince property at Eureka, Colo., and since that time have conducted extensive experimentation on their complex sulphide ore, containing gold, silver, lead, zinc, copper and iron. Definite results have enabled their local manager, MR. M. H. KURYLA, to design and build a 500-ton unit of modern steel and concrete construction, illustrated in Fig. 1, and which will start operations in the spring.

The old Sunnyside mill was modeled along the conventional lines of using stamps for grinding, followed by amalgamating plates and a few tables to clean the overflow. The troublesome iron-zinc middling was later treated in Huff electrostatic machines. The difficulties that had been experienced in making a satisfactory separation between the zinc and the lead, demanded a search for a more efficient separation. This has been found in the selective lead flotation process now being tested in one of the old mills acquired with the property, and which has eliminated the necessity of the static treatment.

SUNNYSIDE 500-TON MILL

The ore will be crushed at the mine in two No. 6-K gyratory crushers, working in series; a 3-ft. x 10-ft. Sheridan shaking grizzly being used between the two crushers to sort out waste and to separate rock for tube mills. The crushed ore will be delivered to the new mill by a 16,000-ft. Trenton tramway, and weighed at the discharge terminal by a Merrick weightometer. There are three 1000-ton cylindrical steel storage bins from which ore is fed by pan conveyors to three 8-ft. x 6-ft. Marcy ball mills working in closed circuit with 6-ft. extra heavy Dorr classifiers. The Marcy discharge, approximately at 20-mesh, will be sampled by an automatic motor-driven sampler, which together with the other samplers in the mill will be actuated by a master clock. That ball mills are being installed in spite of the fact that 100 stamps were available from the Gold Prince purchase is significant of the outcome of the investigations concerning equipment to reduce the ore from 2½ in. down to 20 mesh.

The fine grinding will be done in three 5-ft. x 14-ft. tube mills, using mine rock for pebbles, and one 5-ft. x 8-ft. ball mill. From present indications a considerable economy may be effected by using mine rock, which appears to be especially well suited for pebble grinding. The overflow of the tube mill classifiers will be amalgamated inasmuch as the tests indicate that quite a proportion of the free gold fails to float selectively with the lead. For the present stationary plates will be used.

The selective flotation of the galena, together with a majority of the gold, silver and copper, will be accomplished in one 6-cell, 18-in. minerals separation subaerated machine of the latest Australian bottom-drive type, and one standard 6-cell, 24-in. M. S. mechanical machine. The test-mill results indicate a very fair recovery of lead in the form of a concentrate assaying 65 per cent lead and 5 per cent zinc from a head containing 4 per cent lead.

The tails from the above lead machines will be floated in a 20-cell, 24-in. standard M. S. machine, in which a zinc concentrate will be produced assaying over 50 per cent zinc with less than 5 per cent lead.

Both concentrates will be passed over Wilfley tables, which will be mostly in the nature of pilots. A definite proportion of the final tail from the zinc machines will be passed over a Wilfley pilot table. To thicken the tailings two 40-ft. x 12-ft. Dorr tray thickeners will be used. The lead concentrate will be thickened in a 16-ft. x 8-ft. Dorr thickener and filtered in a 12-ft. x 3½-ft. Portland filter. The zinc concentrate will be thickened in a 25-ft. x 8-ft. Dorr thickener, filtered in a 12-ft. x 9-ft. Portland filter and dried in an Argall dryer, the dryer being available from the old 100-stamp Gold Prince concentrator.

The mill is served by an outside incline track, while the more important floors will be served by electric platform elevators. The small amount of pulp elevating that will be required will be accomplished by means of air-lifts.

Technical Association of Pulp and Paper Industry Meets in New York

The third annual meeting of the Technical Association of the Pulp and Paper Industry was held at the Waldorf-Astoria in New York, Feb. 5 to Feb. 7. The banquet was held at the Hotel Astor on the evening of Feb. 6.

Tuesday afternoon was given over to a meeting of the executive committee and to conferences of chairmen of standing committees.

A general session was held Wednesday morning at which President Henry P. Carruth presided. At this session reports were made by the officers and standing committees, of which there are now fourteen covering all phases of the industry.

On Wednesday afternoon two separate symposia were

held, one on Acid Making and one on Engine Sizing.

At the symposium on acid making the milk of lime and tower system were thoroughly discussed. Mr. E. R. Barker, of Boston, Mass., one of the leading exponents of the milk and lime system, read an interesting paper on that system. Mr. G. D. Jenssen of the G. J. Jenssen Co., New York, presented the advantages of the tower system, chief of which he said was the lower temperature of operation and consequent higher absorption of SO_2. He said the heat of the milk of lime system was also especially objectionable in summer time. Mr. Clinton K. Textor of the Nekoosa-Edwards Paper Co., Port Edwards, Wis., read an interesting paper on some of the theoretical considerations involved. Others who discussed the subject were: P. A. Paulson, Kimberly-Clark Co., Neenah, Wis.; Martin L. Griffin, Oxford Paper Co., Rumford, Maine; H. R. Heuer, Wheat Paper Co., Petoskey, Mich.; S. E. Lunak, Interlake Pulp & Paper Co., Appleton, Wis., and H. F. Obermanns, Hammermill Paper Co., Erie, Pa. A more complete account of this session will be given in a later issue.

At the banquet on Wednesday evening, Judge Charles F. Moore acted as toastmaster, and speeches were made by Dr. Charles H. Herty, editor of the *Journal of Industrial and Engineering Chemistry*, and Arthur F. Sheldon, president of the Sheldon School of Business Science.

First Annual Meeting of Chemical Alliance, Inc.

The Chemical Alliance, Inc., was formally organized at its first annual meeting at the Hotel Biltmore, New York, on Wednesday, Feb. 6. About two hundred were present.

The meeting was opened at 10 a. m. by Horace Bowker, president of the old Chemical Alliance, which was a fertilizer committee exclusively, acting in an advisory capacity to the Government. Chairman Bowker reviewed the events leading up to the formation of the present alliance and the reasons for its inclusion of all chemical and allied industries. An account of this reorganization has been previously given in our columns. The Chemical Alliance, Inc., the present organization was formed on Dec. 4, as we have previously stated, to take over the work of the former Committee on Chemicals of the Council of National Defense. Chairman Bowker explained that the work is varied and complex with respect to the different sections. The Acids Section has had to deal chiefly with problems of production for war purposes, as has also the Alkali Section. The Fertilizer Section, however, which is not directly engaged in producing war materials, has had to deal chiefly with internal problems in the industry, such as coal supply, etc. The organization as a whole is a group of allied industries to which the Government can go and get information on its problems. It has already helped the Government considerably and is ready to help now. When the war is over there will be just as pressing problems as there are at present.

Mr. Henry Howard, vice-president of the old Alliance, followed with a short speech, in which he said that the main problems were those of distribution, obtaining of raw materials and the furnishing of statistics to the Government.

Mr. Charles MacDowell, president of the Armour Fertilizer Works, and now acting in an advisory capacity to the War Industries Board, made a few remarks and urged the fullest co-operation between the Raw Materials and Statistical Divisions of the War Industries Board and the industries represented in the Chemical Alliance.

Chairman Bowker then said it was the controlling view of the present Board of Directors, elected at the organization meeting in December, that the Alliance should represent primarily producers, and no others at the present time. This is subject to modification by the directors at any time, as they have the authority, according to the constitution, to decide on the membership.

The secretary, J. Cameron Bradley, reported that 169 applications for membership had so far been approved. This number has now been greatly increased through further applications.

Mr. D. W. Jayne of the Barrett Co. offered a resolution that no action of the Board of Directors or of any committee shall be binding on individual members, without the consent of the members. The resolution was adopted.

The chairman said that the formation of a vegetable oil, fats and glycerine section was under consideration, as it had been requested by the War Industries Board.

After this preliminary general session the members were split up into their various sections for the election of section chairmen. The following were elected:

Acids Section—W. D. Huntington, vice-president of the Davison Chemical Co., Baltimore, Md.

By-products of Coal and Gas Section—D. W. Jayne, Barrett Co., New York.

Foreign Pyrites Section—A. D. Ledoux, New York.

Electrochemical Section—F. A. Lidbury, president of the Oldbury Chemical Co., Niagara Falls, N. Y.

Fertilizers Section—C. G. Wilson, Virginia-Carolina Chemical Co.

Miscellaneous Chemicals Section—A. D. Rosengarten, Powers-Weightman-Rosengarten Co., Philadelphia, Pa.

Alkali Section—J. D. Pennock, Semet-Solvay Co.

Domestic Pyrites and Sulphur Section—Charles MacDowell, president, Armour Fertilizer Works.

Dyestuffs Section—Election deferred as not enough members present.

The above selections were announced upon reconvening. Election of new officers of the Alliance then took place, which resulted in the election of the officers of the old Alliance, viz., Horace Bowker, president; Henry Howard, vice-president, and J. C. Bradley, secretary-treasurer. The meeting was then adjourned, but most of the Sections met at luncheon and made recommendations to their chairmen, the chairmen meeting at 3.30 p. m. in a general directors' meeting. (Section chairmen are members of the Board of Directors.) At this directors' meeting in the afternoon five directors at large were elected and matters of organization were taken up.

New York Sections of Chemical Societies to Meet

The New York Section of the American Electrochemical Society will hold a joint meeting at the Chemists' Club on Friday, March 1, with the New York Sections of the Society of Chemical Industry and American Chemical Society. An illustrated talk will be given on "A Chemist's View of the Native Industries of China," by H. K. Richardson.

Metallography of Aluminium

Preparation and Etching of Microsections

BY ROBERT J. ANDERSON

RELATIVELY speaking, aluminium has been but little investigated in the metallographic aspect, at least not in any measure comparable with what has been done on iron and steel or copper and brass. It therefore appears safe to say that there exists no metallography of aluminium; references in the scientific literature are scattered and few. This condition appears to be very curious when the importance of the metal as a material of construction for engineering purposes is considered. There have been some comprehensive investigations of certain of the useful aluminium alloys[1] and of some not so useful, but as to the metal itself, i. e., commercial aluminium of say 99 and and over per cent Al, no thorough metallographic work has come to the attention of the writer. On the metal as such, the main work has been done by Brislee[2], while a late paper[3] promises information which should be valuable. Other miscellaneous and scattered data are available, but it appears that a metallography of aluminium is yet to be set forth.

Other than on the metallography of aluminium, there is still room for much work with this metal, as may be witnessed by the fact that one of its most important physical properties; viz., its density, required redetermination as late as 1911 (this work by Dr. Brislee). Knowledge as to the annealing of cold-rolled (partly amorphous) aluminium sheet is still rather vague, and accounts of tests in this regard would no doubt be appreciated.

On account of the large number of engineering uses to which aluminium is being put, it may be that the account in this article will be of interest. A technique for developing the internal structure of aluminium is not so easy as for iron or steel, brass or copper, which ordinarily engage the attention of the metallographic laboratory. Hence, special modifications of the usual metallographic methods must be employed if satisfactory results are to be secured. The present article describes methods for the satisfactory preparation and etching of aluminium microsections.

Pure aluminium when submitted for microscopic examination may be in the form of castings, cold-rolled or annealed sheets, slabs, bars, wires, shapes, etc.; in alloys, it may be in the same forms. As an alloying element, it may predominate or not; where it predominates, the methods hereinafter described for pure aluminium are in general satisfactory, but where it is subordinate to another metal, e. g., copper in copper-aluminium alloys (erroneously termed bronzes), methods and reagents for copper or copper-rich non-ferrous alloys are better suited. This article deals with the metallography of aluminium and its alloys where aluminium is the main constituent.

PREPARATION OF MICROSECTIONS.

The general plan of preparing a metallic microsection is about as follows: (1) selection and removal of a portion of convenient size; (2) grinding or filing a flat surface; (3) polishing that surface; and (4) development of the structure by etching. The ordinary methods of polishing steel microsections will not afford good results with aluminium. Aluminium being rather soft will flow under light pressure, and while a buffing or burnishing action will produce a high polish, which the metal readily takes, heavy pressure will cause blurring of the structure and even local surface hardening. This must of course be avoided.

If microsections from castings are to be examined, they are prepared by the ordinary methods, which are familiar to metallographers, but observing special precautions. When aluminium or its light alloys are polished on fine emery papers (French Hubert Nos. 0, 00, 000, 0000), the surface becomes very dark, in fact almost black; this darkening is ascribed to the emery particles working into the surface of the metal, and becoming embedded there.

A. G. C. Gwyer[4] has written as follows on the subject of polishing aluminium:

> The chief difficulty attendant upon the polishing of pure aluminium and its softer alloys is the trouble which is experienced with the retention in the polished surface of the metal of the emery from the finer grades of polishing papers, as it is practically impossible to remove it subsequently on the wet-polishing wheel. Professor Carpenter has obtained good results by the substitution of ordinary blotting-paper in the place of the final emery-paper, but the writer has never been able to achieve success with this method, and has, in fact, now abandoned dry polishing entirely. With the softest aluminium the writer has obtained excellent results following the procedure here given:
>
> (a) Fine file, kept thoroughly wet with paraffin oil.
>
> (b) No. 1 emery-paper, soaked in paraffin, on wooden board.
>
> (c) No. 2 emery-paper, soaked in paraffin, on wooden board.
>
> (d) Diamantine powder on cloth-covered polishing wheel, kept thoroughly moist with water and also maintaining the supply of polishing powder.
>
> (e) "Globe Metal Polish" on "selvyt" cloth, on polishing-board, rubbing lightly. It may be found on examination that there has been some appreciable surface flow, in which case it is necessary to revert to No. 2, or possibly even No. 1, emery-paper and repeat all the above operations. This does not, however, usually take very long to carry out, and only very light pressure with the hand is required. The final

[1] Carpenter, H. C. H., and Edwards, C. A., Eighth Report to the Alloys Research Committee; Aluminium and Copper; January, 1907.
Rosenhain, W., and Lantsberry, F. C. A. H., Ninth Report to the Alloys Research Committee; Copper, Aluminium and Manganese; January, 1910.
Rosenhain, W., and Archbutt, S. L., Tenth Report to the Alloys Research Committee; Aluminium and Zinc; April, 1912.

[2] Brislee, F. J., A Redetermination of the Density and Coefficient of Linear Expansion of Aluminium; Trans. Faraday Soc., Vol. VII, Part 3, June, 1912, pp. 221-228, with discussion by Seligman, *et. al.*
———, A Redetermination of the Elastic Modulus of Aluminium; Trans. Faraday Soc., Vol. IX, Parts 1 and 2, July, 1913, pp. 155-161.
———, The Density of Aluminium, *ibid.*, pp. 162-173.

[3] Carpenter, H. C. H., and Taverner, L., The Effects of Heat at Various Temperatures on the Rate of Softening of Cold-Rolled Aluminium Sheet; Paper before the Inst. of Metals (London), 1917; and in Eng'ing (London), Vol. 104, 1917, No. 8, pp. Metal Industry (London), Vol. IX, Sept. 28, 1917, No. 3, pp. 260-270.

[4] Hudson, O. F., Etching Reagents and Their Applications. Journ. Inst. of Metals, No. 1, 1915, Vol. XIII, pp. 193-221.

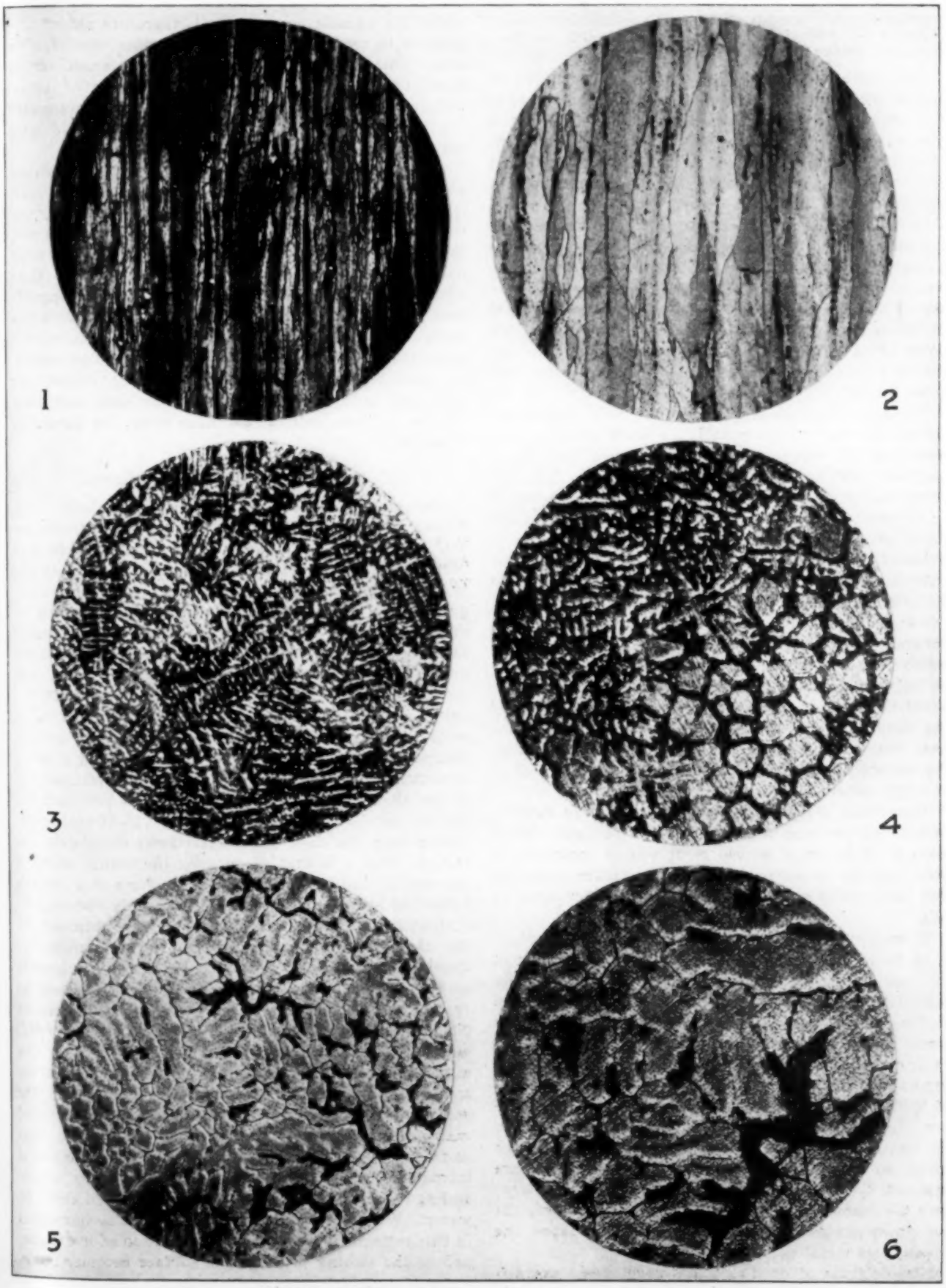

FIG. 1—Cold-drawn bar; 13 per cent Zn and 87 per cent Al; dark deposit resulting from etching with sodium hydroxide; X 150 diameters (after Rosenhain and Archbutt)

FIG. 2—Hot-rolled bar; 5 per cent Zn and 95 per cent Al; dark deposit resulting from etching with sodium hydroxide partially removed by weak chromic acid; X 150 diameters (after Rosenhain and Archbutt)

FIG. 3—Cast-pig aluminium; chill cast; X 40 diameters

FIG. 4—Cast-pig aluminium; similar to Fig. 3, but taken at a point a little further back toward the center of the pig; allotriomorphic grains and dendrites; X 40 diameters

FIG. 5—Sand-cast aluminium; microsection from gate; X 50 diameters

FIG. 6—Sand-cast aluminium; microsection from gate; X 100 diameters

polish before etching for metallographic purposes should be effected with a little metal polish on the finger, rubbing very lightly.

This method, advocated by Gwyer, is very good as anyone who may try it will find. As to the use of blotting paper[5], the writer has never had any success with this material, and supports Gwyer in his abandonment of dry polishing. A method somewhat similar to that of Gwyer, but possibly more rapid, has been developed by the writer, and it has given satisfactory results. This is as follows: preliminary preparation may be carried out by leveling off the surface of a massive section with a plain fine file followed by dry coarse emery paper and then by No. 0 French Hubert. This should be followed by Nos. 00, 000, 0000 French Hubert in succession, but these papers are covered with a thin layer of paraffin. The paraffin film prevents the entrance of the fine emery particles into the metal, and gives a high mirror-like polish.

The finer emery papers are covered with paraffin by simply pouring melted paraffin on their surfaces, and removing the excess with a flat, warmed instrument such as a dull knife or a three-cornered file. The fine emery papers may either be secured to wooden boards or fastened to revolving discs. After polishing on the finest grade of paraffin-covered emery paper, this is followed by polishing on a duck-covered board or disc with fine tripoli and water in order to remove the No. 0000 scratches. The tripoli causes darkening of the surface, but this quickly vanishes when the final polishing is done on fine broadcloth or old well-washed calico with a good non-alkaline metal polish.[6] This may be followed or not by further polishing with No. 3 levigated alumina; or the alumina may be substituted for the metal polish as desired. The above procedure has been found satisfactory, but no doubt various modifications could be employed which would serve as well or possibly better.

Aluminium, being soft, is worn away very rapidly, so that the pressure or rubbing should be light. What amount of pressure to use is of course incapable of definition, but a comparison of the practice employed and the results obtained will determine how hard to rub.

When thin aluminium sheets are to be examined, it is more difficult to obtain a good microsection than in the case of castings or thick slabs. The gages usually submitted for microscopy vary from No. 10 to 28, and in the case of gages from 18 to 28 the thinness of the metal makes preparation troublesome. Sections may be prepared by cutting a strip about 0.75 inch square, bending up the corners slightly so as to afford a means of holding the piece, and polishing in the usual manner. In the case of highly planished cold-rolled sheets, the metal is stiff and hard and also has, as such, a high polish, so that complete following out of the procedure outlined, from file to alumina, may not be necessary; here the coarser grinding may be omitted, and only the two finest grades of paraffin-covered emery paper, the tripoli, and metal polish used.

Microsections of dead-soft thin-gage sheets are difficult to prepare because the metal bends so easily under the lightest pressure; it is therefore almost impossible to retain a perfectly flat surface even if it is once obtained. Small wires can be held in small clamps made of electrician's fibre, as in the case of other metals and alloys. It may be said that aluminium and its light alloys can be rapidly polished by hand, and very good results obtained by that means.

Other methods have been described for polishing aluminium, and Brislee[7] mentions rouge for final polishing. Rouge has never been found satisfactory by the writer; it causes surface darkening, and is therefore not recommended. Polished surfaces vary with polishing powder employed, as is well known[8]; thus silver when polished with rouge is darker in appearance than when polished with white alumina, and the same thing is true in comparing aluminium microsections polished with these two powders. The theory of polishing powders while interesting cannot be discussed here, but the facts in the case are that alumina is more satisfactory than rouge for polishing aluminium.

Etching Aluminium Microsections.

Aluminium and aluminium-rich alloys have been etched by the use of sodium hydroxide, hydrochloric acid, and hydrofluoric acid. Sodium hydroxide has been stated to be satisfactory for developing the structure of alloys of aluminium with zinc, copper, and manganese, but this reagent usually leaves the surface of microsections covered with a black deposit. On rolled and drawn material, this deposit will have a banded appearance. This deposit, according to Rosenhain and Archbutt[9], is of a carbonaceous nature and can be removed readily by immersing the microsection in a weak solution of chromic acid, after etching in sodium hydroxide. This is illustrated in Figs. 1 and 2 after Rosenhain and Archbutt.[10] Fig. 1 is a photomicrograph of an alloy containing approximately 13 per cent Zn and 87 per cent Al, in the form of a 13/16-inch cold-drawn bar; the dark deposit has been completely retained. Fig. 2 is that of an alloy containing about 5 per cent Zn and 95 per cent Al, in the form of a ⅞-inch hot-rolled bar; the deposit has been partly removed.

Ordinarily, satisfactory results may be obtained by the use of both sodium hydroxide and potassium hydroxide, if the black deposit is removed by chromic acid.[11] Sodium hydroxide is used in various strengths from 5 to 20 per cent. Ten per cent cold aqueous NaOH has been employed by Carpenter and Edwards,[12] with an average etching period of from three to five minutes. After trying sodium hydroxide, potassium hydroxide, hydrochloric acid, and hydrofluoric acid for etching a wide variety of forms of pure aluminium and many of its alloys, the writer is of the opinion that hydrofluoric acid is the best reagent. Hydrofluoric acid introduced by Brislee[13]; his reagent was made up by adding one part of fuming hydrofluoric acid to eight of water. When an aluminium microsection is immersed in this reagent, there is a steady evolution of hydrogen, and as the etching proceeds the surface becomes dark-

[5] Mentioned also by Dr. Rosenhain as being used at the National Physical Laboratory, England; private communication August 24, 1917.

[6] After trying a large number of metal polishes on the market a polish called "Magic Metal Polish" was found to be very good; its composition is not known.

[7] Brislee, F. J., *op. cit.* p. 170.

[8] Rosenhain, W., Physical Metallurgy, 2nd ed., New York, 1917, pp. 26-27.

[9] Rosenhain, W., and Archbutt, S. L., *op. cit.*, p. 391.

[10] By permission of Dr. Rosenhain.

[11] This method was devised by S. L. Archbutt of the National Physical Laboratory, England.

[12] Carpenter, H. C. H., and Edwards, C. A., *op. cit.*, p. 254.

[13] Brislee, F. J., *op. cit.*, p. 170.

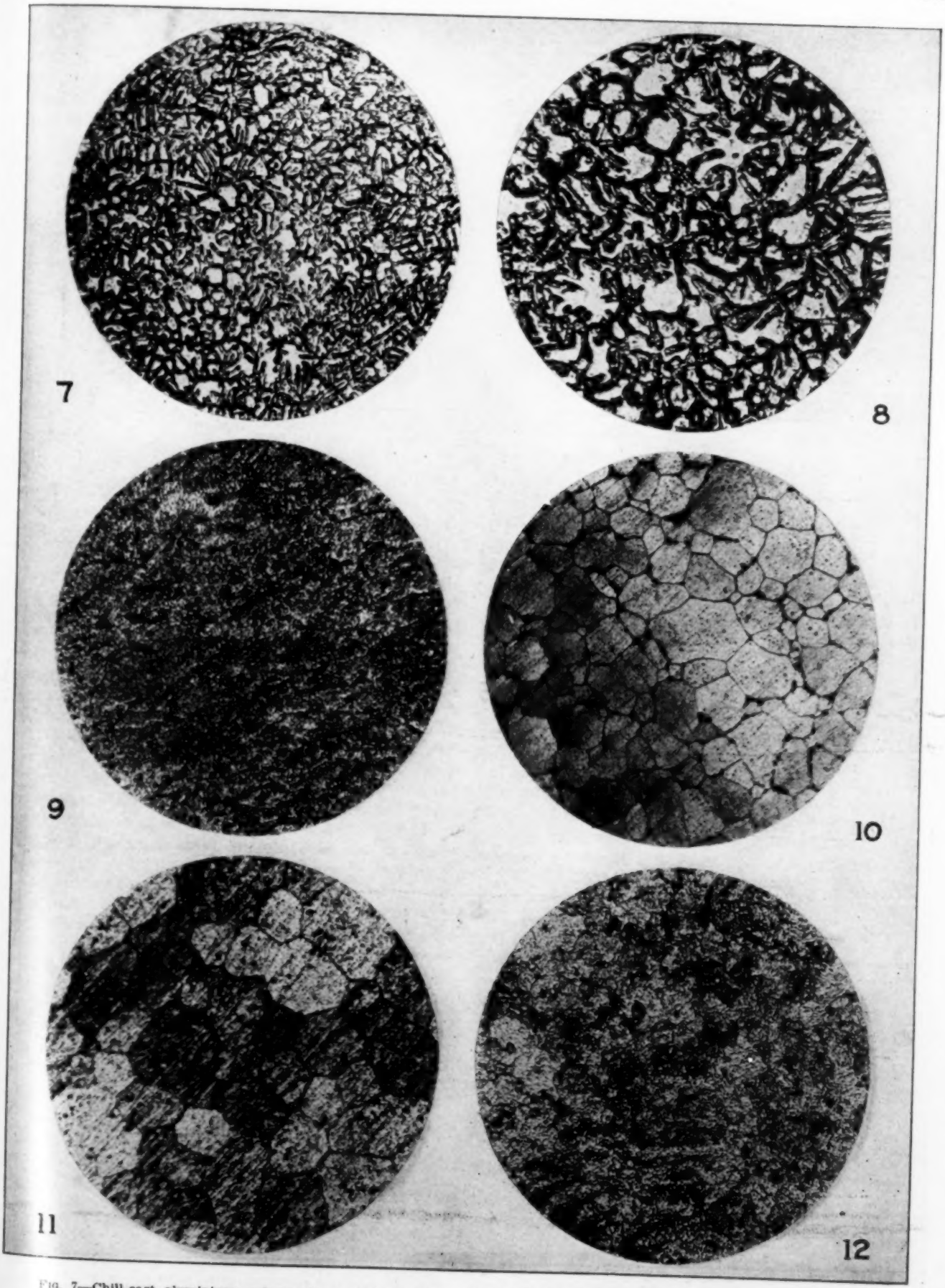

FIG. 7—Chill-cast aluminium; microsection cut from the center of a tensile-test bar (not ruptured) cast in an iron mold; X 50 diameters

FIG. 8—Chill-cast aluminium; same as Fig. 7 but X 100 diameters

FIG. 9—Hard-rolled aluminium sheet; 16-gage; probably mostly amorphous; X 100 diameters

FIG. 10—Aluminium sheet, in annealed condition; reorientation of grains. X 50 diameters

FIG. 11—Annealed aluminium sheet; 16-gage; X 100 diameters

FIG. 12—Hot-rolled aluminium slab; 0.25 inch thick; X 100 diameters

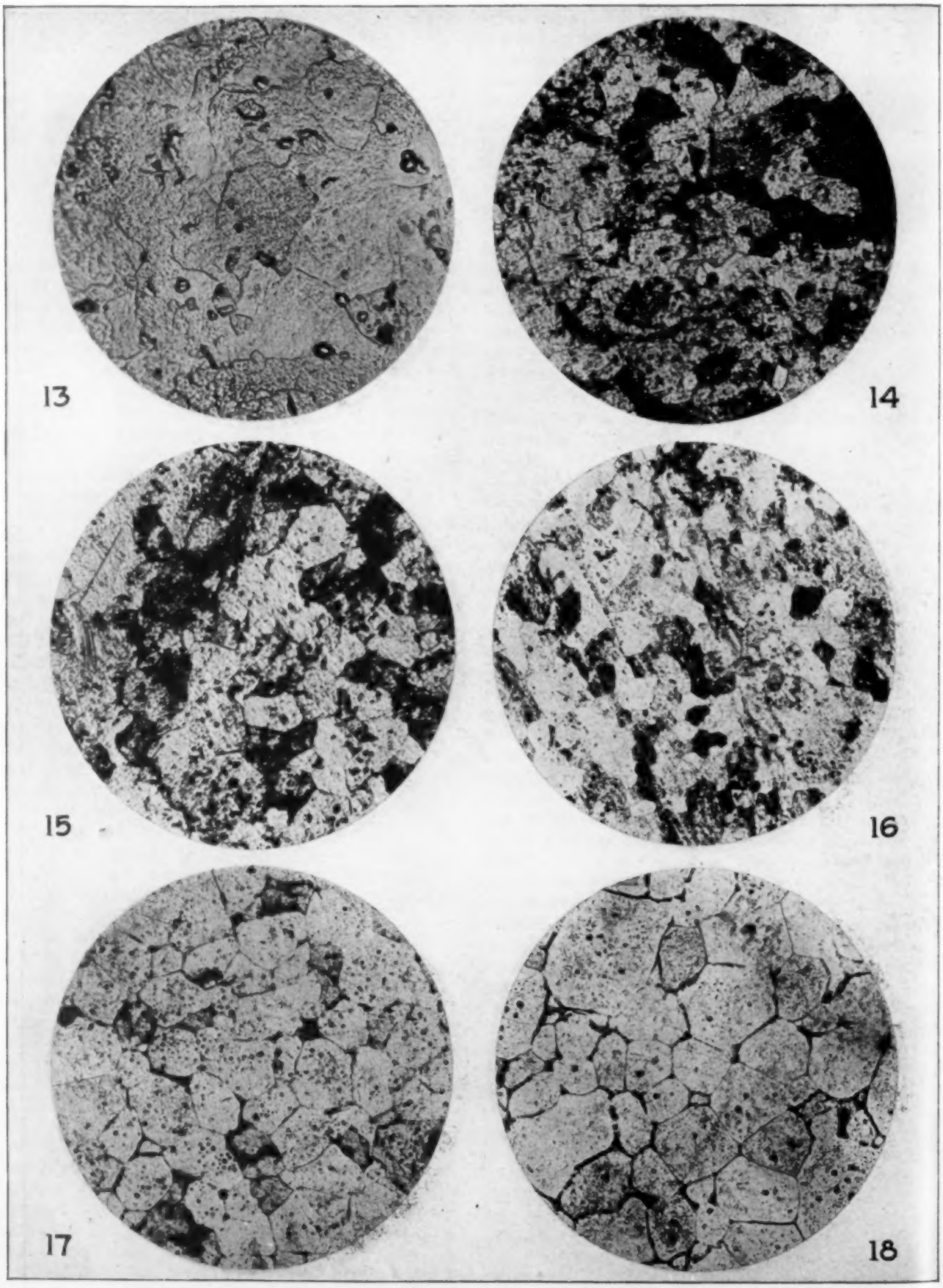

FIG. 13—Hot-rolled aluminium slab; same as Fig. 12, but X 215 diameters

FIG. 14—Annealed aluminium slab; same as Fig. 12 after an exposure of 10 minutes at 485 deg. C.; X 100 diameters

FIG. 15—Annealed aluminium slab; after annealing for 10 minutes at 540 deg. C.; X 100 diameters

FIG. 16—Annealed aluminium slab; after annealing for 10 minutes at 595 deg. C.; X 50 diameters

FIG. 17—Annealed aluminium slab; after annealing for 60 minutes at 595 deg. C.; X 50 diameters

FIG. 18—Annealed aluminium slab; after annealing for four hours at 595 deg. C.; X 50 diameters

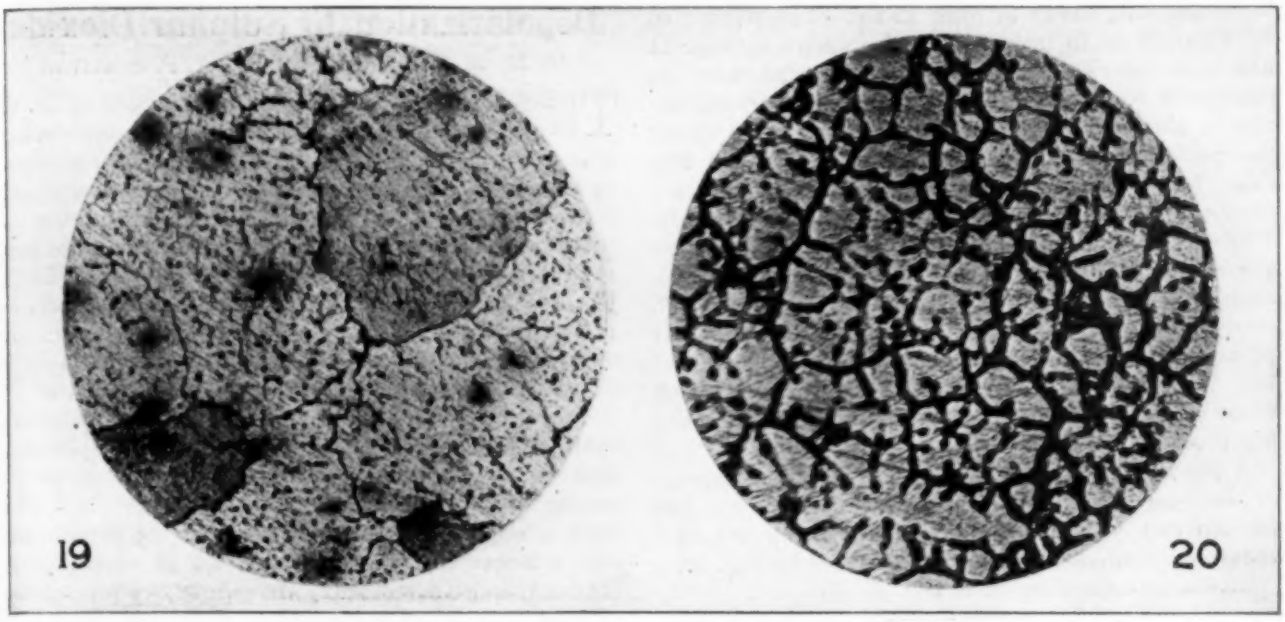

FIG. 19—Aluminium-copper alloy; 4.90 per cent Cu; cast in sand; X 50 diameters

FIG. 20—Manganese-aluminium alloy; 1.65 per cent Mn; chill cast; X 100 diameters

ened, but this darkening is readily removed by an immersion for a few seconds in strong nitric acid.

If a 15 per cent aqueous solution of hydrofluoric acid is used as the etching reagent (made by diluting the ordinary laboratory reagent with water), an etching immersion of about one minute will develop the structure of cast aluminium. The progress of etching may be inspected microscopically or under a low-power lens, and if the structure is not sufficiently developed, the microsection may be etched for a longer period. The questions of strength of acid and period of etching are so very variable that no definite rules can be laid down, nor does there appear to be any necessity for such. Various strengths of hydrofluoric acid may be employed, and the etching period will vary with the strength of the acid. The stronger solutions work more rapidly, and this is a factor in routine work or where a large number of microsections are to be examined.

For containing the hydrofluoric acid, a stock solution may be kept in a paraffin bottle; and for etching, a small amount, say 30 cc., should be poured into a paraffin dish or into a paraffin-coated dish. After etching, the surface of the microsection may be washed in water and then dried in alcohol and ether in the usual way. When properly etched, aluminium is silvery-white in color, and the internal structure may be readily seen under the microscope.

MICROSCOPIC STRUCTURE OF ALUMINIUM.

Photomicrographs in Figs. 3 to 20 inclusive show various forms of aluminium and two alloys; the microsections from which the photographs were taken were prepared and etched by the methods described. Fig. 3 is a photomicrograph of cast-pig aluminium which was poured in a chill mold; freezing was rapid, and the usual allotriomorphic grains typical of pure metals in general are absent; what are present are dendrites, the arms of which are fairly well defined, and which approximate in appearance the frozen ammonium chloride of Rosenhain.[14] The branches or arms from the various crystallization centers are interlocked. Water frozen in street gutters and on sidewalks has at times a like appearance. Fig. 4 shows a photomicrograph of the same metal at the juncture of the dendrites and the allotriomorphic grains (these being common to the interior of the pig); the transition from one structure to the other is marked. Fig. 5 illustrates sand-cast aluminium of high purity; it consists essentially of allotriomorphic grains of aluminium with the impurities segregated to the boundaries; the same thing is shown in Fig. 6, but at twice the magnification. The large black patches are not identified; they may be occluded matter.

Chill-cast metal is illustrated in Figs. 7 and 8; the microsection was taken from a tensile-test bar which had been cast in an iron chill mold. The arms proceeding from various centers of crystallization are very marked, similar to Fig. 3 but quite different from Fig. 5. In Fig. 9, there is shown the appearance of cold-worked aluminium sheet (16-gage), rolled cold from a slab about 0.25-inch thick. No evidence of crystallinity is apparent, and the metal is evidently mostly amorphous; flow lines in the direction of work (from left to right) appear to be distinguishable. The results of annealing cold-worked aluminium are shown in Fig. 10, which is a photomicrograph of annealed 16-gage metal. The difference between Figs. 9 and 10 is plainly evident. Fig. 11 also shows the effects of annealing on cold-rolled aluminium sheet. The degree of cold work in the case of the sheet represented after annealing by Fig. 10 had been greater than in the case of Fig. 11 because of the larger grain size of the former; both samples had been annealed for 15 minutes at 540 deg. Cent. and allowed to cool with the furnace.

When aluminium is hot-rolled, its appearance will be not unlike that in Fig. 12; there is still evidence of crystallinity but the grains have been distorted due to the work. Possibly some self-annealing took place on the metal in question, as the rolling was finished hot—at about 300 deg. Cent. The evidence of partial crystallinity in this metal is better shown in Fig. 13, at a higher magnification. The effects of annealing on the

[14] See Fig. 20, Plate VI, Physical Metallurgy, 2nd ed., New York, 1917.

hot-rolled slab, shown in Figs. 12 and 13, is illustrated by Figs. 14 to 18 inclusive. Metal shown in Fig. 14 had been hot-rolled to a 0.25-inch slab and then annealed for 10 minutes at 485 deg. Cent.; recrystallization is partial but far from complete. Fig. 15 shows the results of annealing the same metal at 540 deg. Cent. for 10 minutes; recrystallization is plainly not complete, but has proceeded further than in Fig. 14. The effects of annealing at still higher temperatures are shown in Fig. 16, where the slab had been annealed at 595 deg. Cent. for 10 minutes, and in Fig. 17, where the slab had been annealed at 595 deg. Cent. for 60 minutes. Hot-rolled aluminium after annealing at 595 deg. Cent. for four hours is shown in Fig. 18, where recrystallization is complete and grain growth has proceeded.

A photomicrograph in Fig. 19 shows the appearance of sand-cast aluminium-copper alloy containing 4.90 per cent Cu, and chill-cast manganese-aluminium alloy containing 1.65 per cent Mn is illustrated by Fig. 20.

Cleveland, Ohio, January 11, 1918.

Fuel Oil Now Under License

A proclamation has been issued by President Wilson placing under license all manufacturers and distributors of fuel oil with sales of more than 100,000 barrels a year. The system went into effect Feb. 11. Fuel Administrator Garfield has compiled a list of activities which will have the preference in receiving supplies of fuel oil. The distribution will be under the direction of Mark L. Requa, head of the Oil Division of the Fuel Administration.

Gasoline and kerosene are not included under the term fuel oil and hence do not come under Government control at present.

The list of preferred activities follows:

1. Railroads and bunker fuel.
2. Export deliveries or shipments for the United States Army or Navy.
3. Export shipments for the navies and other war purposes of the Allies.
4. Hospitals where oil is now being used as fuel.
5. Public utilities and domestic consumers now using fuel oil (including gas oil).
6. Shipyards engaged in Government work.
7. Navy yards.
8. Arsenals.
9. Plants engaged in manufacture, production, and storage of food products.
10. Army and navy cantonments where oil is now used as fuel.
11. Industrial consumers engaged in the manufacture of munitions and other articles under Government orders.
12. All other classes.

The chief reason for the placing in effect of the licensing system is the lack of adequate transportation facilities due to railroad congestion and the use of many tank cars for other purposes. It is also necessary that railroads using fuel oil have a sufficient supply and army and navy requirements must be taken care of.

It is also pointed out that many ships which are normally used for transporting fuel oil have been diverted for other purposes and this helps to make the transportation problem more difficult.

Depolarization by Sulphur Dioxide

By M. de Kay Thompson and A. P. Sullivan

THE following is an extension of the work by M. de Kay Thompson and N. J. Thompson,[1] on the electrolytic oxidation of sulphurous acid. In the former investigation the current efficiencies of the oxidation of sulphurous acid were determined; in the following the object was to determine how much the voltage is lowered at the anode by the presence of sulphur dioxide. The object in using sulphur dioxide as a depolarizer would be primarily to save power, only incidentally to make sulphuric acid; consequently the question here taken up is of greater importance than that in the first paper.

The electrolytic cell used consisted of a porcelain vessel in which a porous cup was placed as a diaphragm. The cell was placed in a cooling vessel. The inside diameter of the cup was 3.8 cm., the height 12.7 cm., when a platinum anode was used. For the duriron anode[2] a larger cup was necessary, 5.6 by 15.4 cm. A copper cylinder surrounding the porous cup formed the cathode. Anodes of platinum and of duriron were used. The platinum anode measured 2.5 by 8 cm., giving a total area of 40 sq. cm.; the duriron 5 by 11 by 0.5 cm., giving a total area of 123.5 sq. cm.

The top of the porous cup was closed by means of a rubber stopper, through which passed the anode, a glass tube for delivering the sulphur dioxide below the anode, a tube for the exit of the excess gas, and another tube for making connection with the standard electrode for measuring the potential of the anode. The standard electrode was mercury covered with mercurous sulphate in one-tenth normal sulphuric acid. This was connected in the usual way to the liquid of the anode portion by means of an intermediate vessel containing saturated potassium chloride, to eliminate the liquid potential. This electrode was measured against a hydrogen electrode with twice normal sulphuric acid. According to Ostwald Luther (3d Ed., p. 445), the cell

$$Hg/Hg_2SO_4/sat.KCl/2nH_2SO_4/Pt + H_2$$

would have the electromotive force 0.692 volt. The value measured was 0.663 volt. Therefore the standard electrode used had the single potential —0.663 volt, referred to hydrogen as zero, the charge on the solution giving the sign. All single potentials are here given on this scale. The current and voltage were measured by Weston portable instruments. The voltage of the cell which consisted of the anode and standard electrode was measured by the Poggendorff method with a Lippmann electrometer. A Weston cadmium cell was used for calibrating the bridge.

The sulphur dioxide was made by dropping concentrated sulphuric acid from a dropping funnel onto sodium bisulphite covered with a little water, in a 500 cubic centimeter flask.

The first runs were made as follows: A constant current was passed through the cell and the potential of the anode measured against the standard electrode for a period of 20 to 30 minutes, without sulphur dioxide. This was done for the whole range of currents used. Then a similar series of runs was made with sulphur dioxide passing through the anode compartment. When this potential became constant it was as-

[1] Met. & Chem. Eng., 15, 677 (1916)
[2] Kindly furnished by the Duriron Castings Co., Dayton, Ohio.

TABLE I—POTENTIALS OF SMOOTH PLATINUM ANODE, REFERRED TO HYDROGEN AS ZERO, IN 10 PER CENT SULPHURIC ACID, WITHOUT SO_2. TEMPERATURE, 17° TO 22° C.

1.25 Amp./dm²		2.50 Amp./dm²		3.75 Amp./dm²		5 Amp./dm²		7.5 Amp./dm²		10 Amp./dm²	
Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts
0	−1.005	0	−1.151	0	−1.168	0	−1.205	0	−1.259	0	−1.357
2	−1.135	2	−1 203	2	−1 207	2	−1 240	2	−1 348	2	−1 429
5	−1.138	5	−1.209	5	−1.229	5	−1.255	5	−1.374	7.5	−1.469
10	−1.154	9	−1.217	9	−1.240	11	−1.284	11	−1.400	11	−1.485
15	−1.163	14	−1.226	15	−1.254	15	−1.299	17	−1.410	17.5	−1.504
20	−1.180	19	−1.226	22	−1.265	21	−1.318	22	−1.415	22.5	−1.504
						25	−1.325				

TABLE II—POTENTIALS OF SMOOTH PLATINUM ANODE, REFERRED TO HYDROGEN AS ZERO, IN 10 PER CENT SULPHURIC ACID, WITH SO_2. TEMPERATURE 14° TO 17° C.

1.25 Amp./dm²		2.50 Amp./dm²		5 Amp./dm²		7.5 Amp./dm²		10 Amp./dm²	
Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts
0	+0.233	0	+0.183	0	+0.157	0	+0.090	0	+0.013
2	+0.221	2	+0.152	2	+0.113	3	+0 052	2	−0.028
5	+0 215	5	+0 140	5	+0.105	8	+0.035	4	−1.63
10	+0.212	11	+0.126	11	+0 091	13	+0.033	Depolarisation ceases	
15	+0.205	16	+0.122	17	+0.086	20	+0.017		
20	+0.205	25	+0.111	22	+0.082				
25	+0.202								

TABLE III—POTENTIALS OF SMOOTH PLATINUM ANODE, REFERRED TO HYDROGEN AS ZERO, IN 16.5 PER CENT $CuSO_4$, WITHOUT SO_2. TEMPERATURE, 13.5° TO 18.5° C.

1.25 Amp./dm²		2.50 Amp./dm²		5.00 Amp./dm²		7.5 Amp./dm²	
Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts
0	−1.196	0	−1.321	0	−1.517	0	−1.697
2	−1.246	2	−1.384	3	−1.584	2	−1.758
5	−1.265	8	−1.423	8	−1.611	8	−1.718
10	−1.281	13	−1.436	13	−1.612	12	−1.709
15	−1.289	19	−1.443	16	−1.612	15	−1.697
20	−1.301	22	−1.446				
25	−1.308						

TABLE IV POTENTIALS OF SMOOTH PLATINUM ANODE, REFERRED TO HYDROGEN AS ZERO, IN 16.5 PER CENT $CuSO_4$ WITH SO_2. TEMPERATURE, 14.5 TO 15° C.

1.25 Amp./dm²		2.50 Amp./dm²		3.75 Amp./dm²		5.00 Amp./dm²		6.25 Amp./dm²	
Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts	Min.	Volts
0	+0.201	0	+0.113	0	+0.051	0	−0.003	0	−0.012
3	+0.192	3	+0.109	3	+0.044	2	−0.014	3	−0 039
6	+0 191	6	+0 104	6	+0 039	5	−0 005	6	−0 039
10	+0 188	10	+0 104	10	+0.034	10	+0.005	10	−0.032
14	+0.195	16	+0.103	16	+0 031	18	+0.042	15	−0.042
20	+0.193	20	+0.099	19	+0 033			18	−0.120
								20	−1.113
								Depolarisation ceases	

sumed that the solution was saturated and that the maximum depolarization had been reached.

As the Tables I to IV show, runs were made with 10 per cent sulphuric acid and a smooth platinum anode, with current densities from 1.25 to 10 amp. per square decimeter. Above 10 amp. the dioxide did not depolarize the anode. With a 16.5 per cent solution of copper sulphate the platinum anode was not polarized at above 6.2 amp. per square decimeter.

These tables are summarized below:—

TABLE V—FINAL VALUES. SUMMARY
SMOOTH PLATINUM, 10 PER CENT SULPHURIC ACID

Current Density Amp./dm²		1.25	2.50	5.00	7.5	10
Potential of anode	Without SO_2	−1.180	−1.226	−1.325	−1.415	−1.504
	With SO_2	+0.202	+0.111	+0.082	+0.017	−1.63
Depolarization		1.38	1.34	1.41	1.43	None

SMOOTH PLATINUM, 16.5 PER CENT COPPER SULPHATE

Current Density, Amp./dm²		1.25	2.50	5.00
Potential of anode	Without SO_2	−1.308	−1.446	−1.612
	With SO_2	+0.193	+0.099	+0.042
Depolarization		1.50	1.55	1.65

With smooth platinum there is therefore a reduction in the voltage of the anode of about 1.5 volts for both sulphuric acid solutions and for copper sulphate solutions, if a certain current density is not exceeded. This current density is between 7.5 and 10 amp. per square decimeter for sulphuric acid and is less than 7.5 amp. for copper sulphate.

This is not in agreement with the observations of Mr. M. R. Thompson,[1] who found sulphur dioxide ceased to depolarize at a current density of 3.23 amp. per square decimeter (30 amp. per sq. ft.), using a platinum-black anode in a solution of copper sulphate, sulphuric and sulphurous acid. When the dioxide ceased to depolarize the voltage increased by 1.5 volts, which agrees with our results, except in our experiments this did not take place at such a low current density. Also Mr. Thompson's single potentials are both several tenths of a volt more positive than ours; the differences between are not affected by this. It is possible the platinum-black electrode used by Mr. Thompson is the cause of the difference, though platinum-black would be expected to depolarize better than smooth platinum.

That the metal of the electrode does determine the current density at which depolarization ceases to take place is shown by the results with duriron, which are given in table VI.

In this table the results were obtained by a different method of measurement. The current given in the first column was applied for one-half minute, and the anode potential then read. The next current applied for the same time, and so on. A similar series was then made with sulphur dioxide.

TABLE VI—POTENTIAL OF A DURIRON ANODE, REFERRED TO HYDROGEN AS ZERO, IN A SOLUTION CONTAINING 10 PER CENT SULPHURIC ACID AND 16.5 PER CENT COPPER SULPHATE $CuSO_4$. TEMPERATURE, 12° TO 13°C.

Without SO_2		With SO_2, Volts	Depolarization
Amp./dm²	Volts		
0.405	−1.403	−0.264	1 14
0 810	−1 510	−0.359	1.15
1.22	−1.581	−0.416	1.16
1.62	−1.623	−0.471	1.15
2.43	−1.667	−0.505	1.09
3.25	−1.707	−2.073	None
4.05	−1.721		

If results could be obtained in practice as favorable as in these small scale experiments, it is evident that considerable saving would result from the use of sulphur dioxide as a depolarizer.

Massachusetts Institute of Technology,
Cambridge, Mass.

[1] Met. & Chem. Eng., 16, 178 (1917).

The Need for Organization in New Chemical Companies*

By FRANK HEMINGWAY

A MATTER that has been uppermost in my thoughts for the past year or so is the lack of organization in many of the new large chemical companies and the necessity of bringing order out of chaos before going much further with the present attempts to bring about nation-wide co-operative effort.

Nearly all of you here to-night are engaged in established and already highly organized industries, and would be apt to class as fairy tales a simple and unexaggerated statement of just a few of the things that have happened in the last three years and are happening to-day, particularly in an industry with which I have been in close touch for some time past, namely, that of the manufacture of coal-tar intermediates and dyestuffs.

Our visit yesterday to the wonderful plant of the Laclede Gas Light Company encourages us to believe that the manufacturers of coal-tar derivatives in this country have little or nothing to fear to-day, or after the war, in the face of world competition. But when we get to the next link in the chain—that is, eliminating the uses of the coke, the town gas and the sulphate of ammonia, and consider what is done with those products described as coal-tar derivatives—we must acknowledge, if we are to be honest with ourselves, that as regards the next two steps, first, the production of intermediates, and second, the manufacture of finished dyes, we are a long way from home.

We may look with just pride on the wonderful progress that has already been made, but to employ a business term, the real progress is decidedly "spotty."

Nothing in the development of an industry of national importance is such a handicap as wrong-minded public action, based on ill-informed public opinion, and I fear that the public generally, and indeed many members of the chemical profession itself, have based their opinion of recent developments on what they have read or heard of the successes made by those old established companies which have made a success and of one or two of the newer organizations which have succeeded.

They have not had presented to them the long list of failures, nor have they any idea of how close to the wind many of the newer chemical industries are sailing to-day, despite the price advantages they enjoy. It is interesting and extraordinarily instructive at this time to read carefully the history of the failure of the British dyestuff industry within a decade or so of the time of Perkin's discovery of mauve in 1856. The financiers and business men in those days blamed the chemist as being an impractical man, and claimed that what little success had been made was due to their own efforts as business men and to the work done by their engineers. The chemists blamed the financiers and the business men, and indeed everybody but themselves, and they all joined in one general condemnation of their government. But one fact stands out, namely: that the most important factor of all was, as I have already expressed it, wrong-minded public action based on ill-informed public opinion.

However, we may claim to an extent that through the work of some of the members of this Institute, and particularly of men like Dr. Charles Herty, the American public is much better informed today than was the British public in the sixties and seventies.

I shall not touch at any length upon that subject which is uppermost in the minds of the members of this Institute, namely, the ethics of the profession, beyond venturing to say, at the risk of making myself very unpopular, that a great deal has been done in the last three years without consideration to professional ethics and business honor. Capital has sunk many millions in enterprises on the advice of professional men who had nothing more than a book knowledge of the particular industry; and, as a consequence, capital today is not so entirely happy about the future of our great chemical industries as it would have been if all their advisers had governed their action by the code of ethics which this Institute has adopted; and although we have not caused these troubles, it seems to me that for the country's good we should do all in our power to correct them wherever possible.

Most of us have heard and used the expressions, "co-operation," teamwork," and so on, until we are heartily sick of them. It has been my experience that business associations are formed with great enthusiasm; the heads of the important companies are all present at the first meeting; the officers are elected; committees are formed; days are spent over the by-laws; much is said about co-operation, and then the big men hand the thing over to their juniors, and little further progress is made. We hear the same old platitudes and vintage bromides, and we know perfectly well that the same old competitive antagonism continues to a large extent.

Surely, the head of the biggest corporation in the world, Judge Gary of the United States Steel Corporation, realized this when he instituted the Gary dinner. There is nothing illegal or in violation of the Sherman Act about men becoming first acquaintances and then friends. What happens when competitors become friends? Not necessarily an illegal price agreement, but a full, frank, honest and open discussion of their common problems.

In the first year of the war such a coming together would have been impossible. Had it been possible there is no question that the aniline oil fiasco would have been avoided. Within an interval of a few months aniline oil dropped from exorbitant prices to less than cost.

I ask you, would men who through their friendships had gained some knowledge in advance of what was likely to happen, have deliberately entered the aniline oil business in those early days? Precisely the same thing happened in phenol.

*An address delivered at the St. Louis meeting of the American Institute of Chemical Engineers, December, 1917.

This kind of competition is the greatest of all business disasters. It results in the closing of plants, the freezing out of the small men, the profitable continuation of the operation of the concern that is financially very strong, and nine times out of ten, as a result of such a business upheaval, with its attendant casualty list, no true technical progress is made.

Our German friends met their problem in a very different way. If a German manufacturer found himself undersold, he concluded that in all likelihood one of two things had happened, either that his competitor had a better and more economical method, or was obtaining his raw material cheaper, and it seems to me that most of them never paused in their efforts to simplify, improve and cheapen their processes.

Now, as I said in the beginning, all this may sound elementary, even rudimentary, to those of you engaged in fully established and highly organized industries, but I want you to realize that tens of millions of dollars are invested in chemical industries in this country under conditions that amount to chaos, and I ask you is it right for us to view calmly the sacrifice of so much capital, so much plant, and so much human effort, even though it may have been ill-directed at the start?

Many of you may think I am drawing the long bow when I make the unqualified statement that I know of many companies of large size whose boards of directors are composed wholly of financiers and business men possessing no chemical knowledge whatsoever, and in which there is no co-ordination between the directing head, the chemists and engineers, or chemical engineers, the sales department and the purchasing department. Companies hear that there is a good and profitable market for a certain product, and after full discussion with their head chemist—who, of course, should be able to produce any chemical product whatsoever; indeed that is what he is paid for—decide to start the manufacture.

There are innumerable instances of large companies that in good faith have entered into contracts for the sale of products which their chemist told them they could produce, only to make cash settlements after months have passed, and the realization was forced upon them that they were unable to produce the goods with the technical knowledge at their disposal.

Yet such concerns blunder along from one mistake to another without taking the simple and obvious step of bringing about co-operation among their own departments and placing on their board the best and most highly trained technical men that they can find.

Surely a scrutiny of the directorate of the leading and successful German chemical companies would at least indicate to these gentlemen that the success of the German industries had to a large extent been brought about by the prominence given in the management of their affairs to men of scientific attainments. It is hard to believe that with such conditions of complete lack of co-ordination or effort under their very noses, in their own establishments, these very gentlemen will give time and thought to such matters as governmental action. It looks like getting the cart before the horse.

About two weeks ago I had the pleasure of entertaining Dr. M. O. Forster, technical director of British Dyes, Limited, and of bringing him together in a social and informal way with the heads of several of the important companies manufacturing intermediates and dyestuffs. Dr. Forster spent a month in this country studying the development of the industry here, and, as I understood him, with one thought in mind, namely, the future of the industry in America, in France and in England, and what was likely to happen after the war. He felt that in the fact that the countries of the Allies could not possibly produce a full line of dyes before the end of the war lay the great danger, for the Germans would sell their small tonnage specialties to American buyers only when the buyers purchased the full line. This condition is described in business as "full line forcing." There is a provision against this in the Clayton Act, and it seems that the crux of the whole matter will be in the enforcing of that provision.

It is evident, however, that some of the larger companies in this country are practising in their domestic trade the very evil against which they seek to protect themselves by legislation. We know of smaller concerns that are producing specialties that are of a better quality than the same product manufactured by the larger companies making a fuller line, but are unable to place them under contract because the buyers fear to split their business lest the larger companies keep from them their full line.

This in itself is a delicate situation, which I maintain would be avoided with advantage to all had all the manufacturers come in personal contact and acquaintance ripened into friendship and led to free discussion.

I fear I have wandered from my subject, which has to do simply with the lack of organization in some of the newer industries, but I could not resist the temptation of touching on these other matters.

To summarize the conclusions I have drawn from my observations in the last three years, I might say first that the members of such an influential body as the American Institute of Chemical Engineers should individually do all in their power to hold the confidence of the public, the business men and the financiers in the development of the newer chemical industries, and to offset as far as possible the damage that has been done by the action of professional men not qualified to advise on particular industries, but who nevertheless have not hesitated to involve large sums of money in development. Second, that for the nation's good the individual members of this Institute should do all in their power, and without regard to their own pecuniary advantages, to educate public opinion, the business men, and the financiers, to a correct understanding of the problems they face, with a view to bringing true scientific and technical order out of the chaos which exists in so many cases, and to make clear in fact to some of the more complex organizations that although the solution of one technical problem is important, it is more important to first perfect the co-ordination of all departments so that finances, business policy, scientific control, utilization of waste products, sales and purchases, work together as a solid unit to grapple and solve all problems presented.

115 Broadway, New York.

The Nichols Medal for 1917 has been awarded to Dr. Treat B. Johnson of the Sheffield Scientific School of Yale University. The presentation will be made on March 8, 1918, in Rumford Hall, Chemists' Club.

Efficiency in Industrial Research

By Charles W. Hill

THE establishment of many new industrial research laboratories in this country during the past two years, especially by concerns not directly connected with war products, will be noted with satisfaction by technical men. However, it is to be regretted that many of the older laboratories are not operating on a high plane of efficiency and that many of the newer ones have been started as experiments without due consideration of the experiences of the older organizations. The time appears to be ripe for a discussion of the various factors which influence the efficiency of industrial research, and for crystallizing the experiences of those who have been engaged in such work for some time, so that new laboratories may avoid the errors of the old and that the efficiency of others may be increased.

The following may be mentioned as among the more important factors: the relation of the laboratory to the general organization, the attitude and policy of the management, the selection of laboratory director, the selection of research men, problems and methods of work, and details of laboratory management.

Relation to the General Organization

The efficiency of a laboratory seems to be influenced in no small degree by its position in the general plan of organization of the company. The arrangement which is almost certain to give the best results constitutes the laboratory as a separate department occupying the same relative position in the organization as that of the production or sales departments, with the laboratory director responsible to the general manager. As a rule, the interposition of officials between the general manager and the director tends to lower the laboratory efficiency, although there appear to be exceptional cases where such an arrangement may not seem feasible.

A somewhat common and invariably a serious mistake is that of placing the laboratory under some branch or department of the concern. Frequently it is placed under the factory or production management. The idea back of such an arrangement is the fact that many if not all of the problems relate to the factory in some way or other. Experience shows that this is the very reason why the laboratory should not be under the factory management. It should be absolutely free from influence of a compulsory nature from any source, be it factory, sales or purchasing departments. Its success is attendant on the full co-operation with all branches of the organization; and this is best obtained when it is subject to none of them.

The attention of the writer was called to a large laboratory which is under the factory management, a large part of its time being devoted to rendering aid to a weak factory organization. Although the process is one of many years' standing, continuous help is required of the laboratory to maintain production, without the laboratory being allowed to make the changes necessary to place production on a firm basis. At the same time, each laboratory man is cautioned against breathing a word about actual factory conditions to anyone outside the factory management. If this laboratory were independent of the factory, it could soon bring about the desired changes in factory affairs. The benefits thus to be derived by the company as a whole, by the factory and by the laboratory, are obvious. The position of this laboratory in the general organization prevents it from doing good where it is most needed.

Attitude and Policies of the Management

The attitude and policies of the management regarding the laboratory are naturally of the utmost importance. Some managements expect a laboratory to be an immediate source of profit to the company. They sometimes expect wonderful and profitable results within a very short time and with a relatively small expenditure. As a rule, this can not be. It would be a sad commentary on the factory and technical men who have been in the business many years if a research laboratory could uncover startling discoveries regarding an old process in a short period of investigation. If money-making discoveries are possible with a small expenditure of time and money, every research man in the country would be experimenting on his own account in his cellar or attic if he could not afford a better place. Barring virgin fields, industrial research does not, as a rule, bring immediate results commensurate with the cost. It is therefore necessary for ultimate success that the general management foster research generously and wait a reasonable time for returns. One may possibly secure some profitable returns within two or three years after a well equipped laboratory is in full swing. Industrial research resembles mining. One must clear away the site, get down to the ore and get the machinery running before our mine will pay a dividend. The pay-dirt is seldom on the surface.

A niggardly policy in the matter of securing apparatus for efficient work and of paying salaries necessary to engage and retain men of quality results in inefficiency and unsatisfactory returns. This does not mean that one should go to the other extreme of unlimited expenditure and no accounting of progress to the general management. Any fair-minded director stands ready at any time to take the responsibility for his methods and expenditures, provided he is given authority over them; but he cannot successfully direct research if he is required to fight for each piece of apparatus or every increase in salary for his men.

A rather generous policy regarding the men in the laboratory is usually productive of the best results. This applies to such matters as working conditions, of hours, vacations and clean, healthful laboratories and offices, the publication of papers not of secret value, financial assistance to men attending meetings, etc.

The Selection of Director

The selection of a director is a vital matter in the establishment of a laboratory, and it is one in which a company can easily make a mistake. A common error is to transfer a chemist or engineer from routine or factory work into research work as a director. Another mistake is the selection of a man who has made a reputation in individual research but who has not had experience in working with or directing the work of others.

The personality of a director is of importance sec-

ond only to proper training and research experience. A director should be a good judge of men and able to manage as well as to inspire them. He should be a leader rather than a driver. Furthermore, he should be a man who is inclined to be independent and not in the least fearful for his own position. This enables him to present the requirements of the laboratory to the management and if necessary put up a good fight to carry through those matters which he knows are important. Being certain of his own standing, he can allow credit to fall on the men under him, taking his own credit for the harmony and general efficiency of the laboratory as a whole. Since his men look to him for advancement, he must be able to judge the merits of the individual and his work and not be influenced by "taffy" or design.

Selection of Research Men

As a general proposition, it is cheaper and more satisfactory to engage experienced research men than to train novices. A successful organization consists of experienced research men in charge of the various divisions of the laboratory with younger and less experienced men as their assistants.

The personality of the research man is of great importance. Men should be chosen carefully, and all should be on a kind of probation basis, especially with reference to their attitude and their ability to fit into the organization. Men who do not mix well with the others, who start dissension, who "blow" or "bluff" or who are confirmed "knockers" should not be retained on the staff. Good laboratory spirit and teamwork is of inestimable value and unfortunately is not always found in industrial laboratories.

In engaging new men, it is better to pay them the salary they ask if it is not unreasonable and to impress them with the necessity of demonstrating their self-appraised worth than force them to accept a lower salary than they feel they deserve. When true merit is involved, the greater returns due to proper spirit of the worker and his aim to make good will more than balance the difference in salary.

Problems and Methods of Work

The nature of the problems to be investigated by a particular laboratory will naturally depend on the extent of fundamental information in possession of the company regarding its process and products. Usually a new laboratory finds many problems of a practical nature awaiting solution. Factory problems as a rule give the laboratory a higher percentage of positive results than do other classes of problems, and hence they afford greater opportunity for returning a good profit to the company for the minimum of effort. However, it is a serious mistake to limit a laboratory to such problems. A certain proportion of men should be engaged with problems of a fundamental nature which carry the investigator into new fields. Such work is the most probable source of new processes or products which can be protected by patents and which protect the company against future competition in its field. Where necessary for the complete understanding of a practical problem, it is profitable to carry a certain amount of theoretical experimentation. There are those who argue for a complete separation of the two kinds of problems, even going so far as to maintain entirely separate laboratories. This would seem to the writer to be a rather arbitrary division and usually not to be advised. It is often highly desirable for the man on a practical problem to conduct theoretical experiments for some time, and it is often as desirable, if not necessary, for the experimenter on so-called pure research to follow the practical applications of his discoveries. It is difficult to see any reason for the attempted division. A well organized research laboratory has its analytical division which can be made large enough to handle the necessary control work for the factory, and there is a distinct advantage in having the control laboratory free from the factory.

There is no good reason for the objection of some investigators to so-called practical problems other than the fact that they frequently lead to results which cannot be published on account of their commercial value. There is, however, a serious objection to the manner in which some managements desire such problems to be handled. Regardless of the nature of the problem, scientific methods of research should be applied with smallest practical amount of the cut-and-try variety of research. Here is the place where officials have been known to interfere with the laboratory to the detriment of research and with loss to the company. It is an interesting although unpleasant fact that some managers, who would unhesitatingly swallow whatever medicine a physician prescribes, will attempt to prescribe methods of research to technical men of far greater comparative training and experience than possessed by the physician. Regardless of the nature of the problem, suitable equipment should be provided and proper methods of research should be followed.

Processes developed in the laboratory should be expanded to a semi-factory basis before final adoption in the factory. When they are finally placed on a factory scale they should be operated for a time by the laboratory before the regular production department takes charge. A division of responsibility or the introduction of research problems into the factory in this connection is likely to cause trouble.

Details of Laboratory Management

Cost Accounting

In all laboratory work fairly accurate records should be kept of the cost of time and materials. This enables the management to control the amount expended on any problem, and at the same time gives the laboratory credit for time spent on factory troubles and consultations which would otherwise be charged to research. There are three common methods of laboratory accounting. According to the budget system, the management appropriates a sum of money to cover all research expenses for a given period and makes the director responsible for the distribution of the total appropriation among the various problems. Frequently a separate appropriation is made for apparatus. The appropriation system is the budget system applied to individual problems, each problem being granted a sum of money and being assigned a time limit. When either the time or the money has been used, a further appropriation is required before the work progresses. According to the third system, accurate accounts are kept of the cost of each of the more important lines, and the monthly expenses of the laboratory are distributed among the various accounts. The manage-

ment may then urge expansion on some problems or the curtailment. The particular method of financing the laboratory does not seem to have any great effect on its efficiency, as long as the proper apparatus is supplied as needed, and as long as some accounting system is used.

OUTLINING OF WORK

Regardless of the experience of the individual worker, it is always advisable to have his work outlined in advance. This is not only better for him, but it affords a reliable record for patents in the case inventions arise from the work. Two systems commonly used are the Conference System and the Proposal System.

In the former, the subject of a research is discussed in a regular weekly or monthly conference among men from the laboratory, factory and patent department; stenographic notes being taken of the discussion. Results are presented by the research man and further work is planned by the conference. There are several objections to the system, of which may be mentioned the loss of time through arguments and futile discussions, the difficulty of directing discussion and of reaching a clear-cut decision, the loss of time in consideration of hastily made suggestions, and the feeling among many research men that the system removes personality from their work. Even the best conducted conference system is likely to follow the research more than direct it. This system alone does not appear to be as satisfactory as the combination of it with the proposal system.

According to the latter plan, a proposal for research is made by the research man and approved by the director. This consists of an outline showing the object of the proposed work, a reference to the previous work leading up to it, a statement of the principle or theory involved, an outline of the variables to be studied together with tests and methods. This outline may be made after conference with the director and others interested in the problem. When the proposed work is completed the results are summarized and further proposals made. Conferences are held when the research man is in need of suggestions as to methods of attack or of information from certain departments. Suitable arrangements are usually made for handling small problems and rush jobs without a proposal; but if such work involves much time or expense it should be outlined. An experienced investigator usually outlines his work and so does not object to submitting his outline for record. Some inexperienced research workers have been known to object to the proposal system and have urged that they be allowed to proceed without direction. This would obviously be dangerous for them as well as for the laboratory.

REPORTS

Reports should be carefully and completely written, and as their volume increases, abstracts and cross references should be made. The amount of useful data which can be buried for years, duplicated or misapplied because of faulty reports is often as surprising as it is disheartening. The cost of properly recording a piece of research so that it will be of value in future years is usually an insignificant part of the total cost.

Industrial research eventually pays and pays liberally if properly executed. It not only assists in raising the quality of a product and in lowering the cost, but it is the source of new products, new applications of old products, and of improvements and inventions which safeguard the future of an industry. It benefits the sales department by furnishing technical information and it inspires in the sales force a confidence in the leadership of their firm. It is a necessity in a modern business of magnitude, and has proved its worth even under unfavorable conditions. Its greatest possibilities are attained only under the proper conditions of management and surroundings, some of which have been outlined in the above discussion.

Pittsburgh, Pa.

Explosives and Ingredients Requiring Licenses

The Bureau of Mines has issued a list of articles requiring licenses under the Act of Congress prohibiting the manufacture, distribution, storage, use and possession in time of war of explosives and ingredients thereof. The list follows:

Explosives

Ammonium nitrate.
Blasting powder.
Caps:—Blasting, detonating, percussion—all classes.
Detonating fuse, or cordeau detonant.
Detonators.
Dynamites.
Electric blasting caps and electric detonators.
Fireworks and flash-light powders.
Fulminates.
Fuse of all varieties.
Gun cotton.
Gun powder and gun powder mixtures (except small arm or shot gun cartridges).
Nitro celiulose and nitro glucose.
Nitro glycerine (except in official U. S. Pharmacopoeia solution, or in form of pills, or granules containing not more than 1/50 grain each).
Nitro-glycol, -mannite, -starch, and -sugar.
Permissible explosives.
Ammonium picrate.
Picrates.
Picric acid.
Smokeless powder (except small arms and shot gun cartridges).
Trinitrotoluol.
Trinitrocresol.
Trinitronapthaline.
Tetranitroaniline.
Tetranitromethylaniline.

Ingredients

(List approved Jan. 5, 1918)

The purchase, possession, sale or use of anyone of the ingredients herewith listed below in amounts of *one ounce or over* requires a Federal Explosive License.

Bichromates:—Ammonium, potassium, sodium.
Chlorates:—Barium, potassium, sodium, strontium.
Chromates:—Ammonium, barium, calcium, chrome green, chrome yellow, lead, potassium, sodium.
Nitrates:—Ammonium, barium, copper, ferric, lead, magnesium, nickel, potassium, silver, strontium.
Nitric acid:—Aqua fortis, fuming, nitric acids of all grades and strengths, mixed acids.
Perchlorates:—Perchloric acid, potassium.
Perborates:—Magnesium, sodium, zinc.
Permanganates:—Calcium, potassium, sodium.
Peroxides:—Barium, calcium, magnesium, oxon (cubes and cartridges), sodium, strontium, zinc.
Phosphorous.

Licenses may be obtained from local federal licensing agents. Application must be made in person by duly authorized officers of companies. The licensing agent for New York is J. R. Healy, Municipal Bldg., and for Brooklyn, John F. Dixon, 365 Jay Street, Brooklyn.

The Third Annual Lyons Fair will be held March 1 to 15, 1918, at Lyons, France. The first two were held in 1916 and 1917 and were very successful. No American companies participated in 1916, but in 1917 thirty-three concerns were represented. This year a much larger representation is expected. Mr. George B. Van Cleve, 1790 Broadway, New York, is chairman of the American Committee.

Grain-Size Measurements

By Zay Jeffries

MANY grain-size determinations by the method described by the writer, A. H. Kline, and E. B. Zimmer* have led to certain refinements in manipulation. Of the several methods tried, the following is recommended as the most satisfactory:

A circle 79.8 mm. diameter is drawn on the rough side of a ground-glass screen, the center of the circle being near the center of the rectangular section of the screen. This ground glass is mounted in a frame which fits a metallographic camera, the smooth side of the glass being on the outside. When the image of the specimen for grain-size determination is focused on the screen the circle will be plainly visible and its circumference should be well within the image.

When the image is properly focused the grains intersected by the circumference of the circle are checked and counted. Since the check marks must be made on the smooth side of the glass, a soft red pencil such as is used in laboratories for marking beakers and flasks will be found satisfactory. The marks used to indicate the boundary grains are usually short, straight lines intersecting the circumference of the circle and perpendicular to it. The completely included grains are next checked and counted, after which the red marks are erased from the glass with a dry cloth. The specimen can then be moved and other measurements made as desired. The idea of putting the rough side of the ground glass with the circle drawn on it to the inside of the camera was suggested by W. T. Burgoon.

In the early experiments the equivalent number of whole grains within the circle was obtained by adding 0.6 of the boundary grains to the completely included grains. The factor 0.6 was used as the result of about 200 determinations which showed an average factor of 0.58. The accuracy of the work involved did not justify the use of a factor of two figures, so 0.6 was chosen in place of 0.5.

I am pleased to state that further careful measurements show that the factor 0.5 is actually more nearly correct than 0.6. The factor 0.5 is more convenient to use, since the boundary grains (usually less than 50) can be divided by 2 instead of multiplied by 0.6. It is true that either factor gives results somewhat more accurate than a specimen can be sampled and in some cases more accurate than the grains can be distinguished, but we now have experimental justification for using the more simple factor.

*Trans. A. I. M. E., Vol. LIV, pp. 594-607. The author's method is recommended by the American Society for Testing Materials, *Proceedings*, Vol. XVII, 1917, Part I, Tentative Standards.—Editor.

TABLE I

Magnification Used = m	Diameter of Circle in Millimeters	Multiplier to Obtain Grains per Square Millimeter = f
Full size	79.8	0.0002
10	79.8	0.02
25	79.8	0.125
50	79.8	0.5
100	79.8	2.0
150	79.8	4.5
200	79.8	8.0
250	79.8	12.5
300	79.8	18.0
500	79.8	50.0
750	79.8	112.5
1000	79.8	200.0
1500	79.8	450.0
2000	79.8	800.0

The use of the factor 0.5 in place of 0.6 does not in any way affect the use of the table of multipliers from which to obtain the number of grains per square millimeter at any given magnification. If the equivalent number of whole grains within the circle measured at a certain magnification be multiplied by the number in the third column of Table I opposite the magnification used, the product will be the number of grains per square millimeter.

A circle 79.8 mm. diameter has an area of 5000 sq. mm. If it is desired to use a rectangle in place of a circle for the determination, convenient sizes will be found in Table II.

TABLE II

Convenient Sizes of Rectangles for Grain-Size Determination

70.7 x 70.7 millimeters	55 x 91 millimeters
65 x 77 millimeters	50 x 100 millimeters
60 x 83.3 millimeters	

Since each of these rectangles has an area of about 5000 sq. mm., the multipliers given in Table I can be used for any of the rectangles in Table II, or any other rectangle having an area of 5000 sq. mm. To make a grain-size determination, with a rectangular in place of a circular area, the grains intersected by the periphery of the rectangle should be counted, one-half the number added to the completely included grains and the result will be the number of equivalent whole grains within the rectangle. If the determination is made at one of the magnifications given in Table I, the number of grains per square millimeter can be obtained by multiplying the equivalent number of whole grains within the area by the multiplier (f) opposite the magnification used. The rectangle could be used on a ground glass as described above for the circle or it could be used on a micrograph.

Brass metallographists do not use the magnifications given in Table I, so a separate table would be necessary for their purposes. Also, some metallographists prefer to refer to the grain size in terms of the diameter of the average grain in millimeters or the area of the average grain in μ^2. The following simple formulas will be found helpful in these cases.

w = boundary grains.
z = completely included grains.
x = equivalent number of whole grains in 5000 sq. mm. (circle 79.8 mm. diameter or rectangle having area of 5000 sq. mm.).
m = magnification used.
f = multiplier to obtain grains per square millimeter.
n = number of grains per square millimeter.
d = diameter of average grain in millimeters.
a = area of average grain in μ^2.

$$x = \frac{1}{2}w + z$$

$$f = \frac{m^2}{5000}$$

$$n = fx$$

$$d = \frac{1}{\sqrt{n}}$$

$$a = \frac{1{,}000{,}000}{n}$$

Cambridge, Mass.

Some General Aspects of Evaporation and Drying*—II

By Hugh K. Moore

(*Concluded from page* 133)

Phenomena in an Evaporator Tube

THERE is a limit also to the amount of evaporation which can be done in a tube in comparison to the volume of liquor circulating through the tube. Generally speaking, the economical operation of such evaporation is limited to that point where incrustation on the tubes due to evaporation commences. It may be asked why this point should arise, or why an evaporator should be run in such a way as to approach this limit, when we know that as we approach it we add operating and mechanical difficulties to those which we already have in sufficient abundance. The answer is that unfortunately some liquors have such foaming tendencies that no way has yet been discovered to evaporate them without conducting the operation in such a manner as to make this point of vital importance. As an illustration it might be said that the writer had designed, built, and operated evaporators with tubes 2 in. in diameter and 7 ft. in height, and in which the liquor inside the tube rises only 3 in. above the bottom tube sheet. These levels, of course, were measured before steam was turned on and ebullition commenced. Foam, in the sense as used in evaporation, may be considered as a globule of vapor surrounded by a film of liquor. By keeping the level of the liquor low in the tubes the unbalanced pressure on the liquor entering the tube is reduced. The foam formed in the bottom part of the tube rushes up through the hot tube, and part of the fluid in the films is evaporated, thus increasing the relative amount of vapor and decreasing the amount of fluid. A point is reached where the volume of vapor is so great as compared with the volume of the remaining liquor that this liquor can no longer stretch as a continuous film about the vapor, and its separation may be accomplished. There is an all-too-common fallacy that increasing the height of the steam dome over a foamy liquor will decrease the foam. It cannot be done in this way, and a little consideration of the principles involved will convince the most skeptical of the fact. If the height of the liquor in the evaporator is increased the volume of the bubbles is decreased by the static pressure, according to Boyle's law, which, as the temperature is constant, may be written $PV = C$, where P is the pressure, V is the volume, and C is a constant. Then the volume of the bubbles is inversely proportional to the absolute pressure. If the static head is sufficient, the heat transmitted through the tubes may be absorbed in the liquid at a low zone without the liberation of vapor. As the liquid travels upward the static pressure becomes less, until at a certain point vapor can be liberated; this vapor constantly increases in volume until the surface is reached. It is evident from the above that increasing the height of the dome above the heating surface only changes the zone of the foam but not its quantity.

The height of the liquor above the tubes may in some cases be a very important and in some cases a controlling factor. For example, let us consider a case in which the liquor reaches a state of saturation for one ingredient long before the desired concentration of another ingredient is obtained. Such an example might be, for instance, the concentration of a solution containing both caustic soda and sodium chloride. Here, as evaporation proceeds, salt is precipitated, while the caustic soda remains in solution. Now, these sharp crystals of salt at a high velocity exert an abrasive action on the tubes.

Chart 7 is submitted principally for the purpose of illustrating this point. The conditions assumed for the calculations of this chart are: the evaporation of water alone under a vacuum of 6.35 in. mercury, boiling taking place at 212 deg. under 7.5 ft. static head, diameter of tubes 2 in., length of tubes 7 ft., thermal coefficient chosen more or less arbitrarily as 300 B.t.u. per square foot per degree Fahrenheit, average temperature difference of exchange 10 deg. Fahr. No account is taken of the increase in conductivity due to increased velocity.

An examination of this graphic shows that so long as the static head is sufficient to keep the heat in the water instead of forming steam there is no change in the velocity of the liquor in the tube, viz.: with a static head above the tubes of 7.5 ft. of water the velocity is about 0.65 ft. per second, and this is the same for 8.5 ft. static head of water. If, however, there is a static head of only 1 ft., the velocity of liquor entering the tubes is 7 ft. per second, and the velocity of the mixture of steam and liquor leaving the tubes 10 ft. 4 in. per second. Now, let us apply this to the caustic soda illustration, remembering that this chart is only illustrative of water, and that the values would be different for caustic soda, but that the underlying principles are the same.

Where heat is transmitted to the caustic, but steam is not formed, the salt remains in solution, and it is only upon the transformation of the water into steam that the salt is deposited. If this transformation takes place in the tube, the salt is deposited in the tube, and at the high velocity shown exerts an abrasive action on the tube which increases toward the top of the tube owing to the increased velocity. This velocity may, in some cases, reach the proportions of a continued explosion.

In the other case, where the liquor is not transformed into steam in the tubes, it circulates upward until finally as the static head is reduced to the limiting value steam is liberated above the level of the tubes entirely and the salt is deposited where there are no tubes to cut out. Now, much of this salt can be settled out, and what remains travels through the tubes at such a low velocity that it has no cutting action.

The writer has seen many tubes cut off at the top due to the explosive action of steam and salt, while the middle and bottom of the same tubes would show only the slightest wear.

Compare Chart 8 with Chart 7. The only difference in the conditions is that in Chart 8 the tubes are 4 in. in diameter instead of 2 in. The effect of decreasing the velocity is apparent, and needs no further comment.

The shape or surface of the tube may, in some cases, be the controlling factor. Thus, if a corrugated tube is compared with a smooth tube of the same size and of

*A paper read at the St. Louis meeting of the American Institute of Chemical Engineers, December 7, 1917.

the same material, it will be found that at low velocities the thermal coefficient of the corrugated tube is greater than that of the smooth tube. At high velocities the reverse is the case. With the corrugated tube the maximum thermal coefficient is reached quickly, and at higher velocities may remain constant or even drop. While the writer's data on this point is, unfortunately, not complete enough to warrant graphical presentation, he has never yet found such a maximum conductivity in a smooth tube.

Calculation of Temperature Differences

In the design of evaporators one of the necessary factors employed in the calculation is the mean temperature difference. Chart 9 shows graphically the varying conditions one may have. Fig. 1 shows a condition where there is a hot medium imparting heat to a cold medium flowing either direct or counter current, and yet no change in the temperature of either. In other words, the temperature difference at any point in the flow is equal to the mean difference. An example of such a condition would be found when one had melting ice in contact with one side of a partition and saturated steam on the other side.

Figs. 2 and 3 are examples in which the temperatures of the media change, but the temperature difference remains constant. A concrete example would be a counter-current exchanger in which the hot liquid entered at 80 deg. and left at 60 deg., and the cold liquid entered at 40 deg. and left at 60 deg. In all of the above cases it is a very simple matter to get the mean

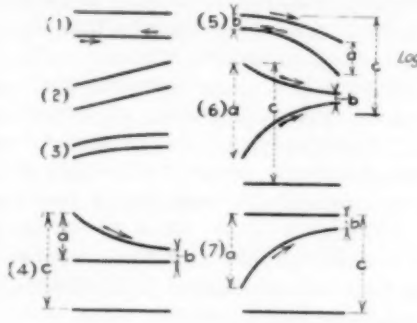

FIG. 9

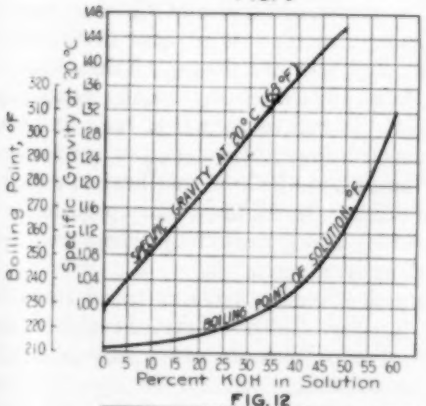

FIG. 12

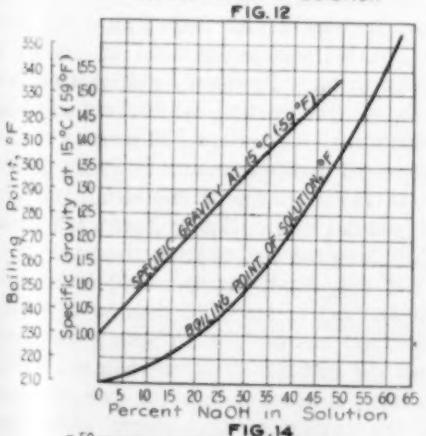
Boiling Point, °F
Specific Gravity at 15°C (59°F)
SPECIFIC GRAVITY AT 15°C (59°F)
BOILING POINT OF SOLUTION °F
Percent NaOH in Solution

FIG. 14

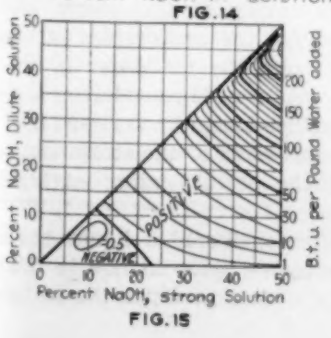

FIG. 15

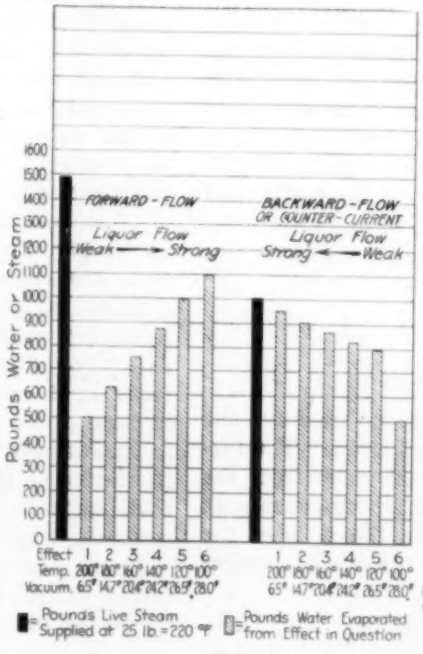
Pounds Water or Steam
FORWARD-FLOW
BACKWARD-FLOW OR COUNTER-CURRENT
Liquor Flow Weak → Strong
Liquor Flow Strong ← Weak
Effect 1 2 3 4 5 6
Temp. 200° 180° 160° 140° 120° 100°
Vacuum. 6.5" 14.7" 20.4" 24.2" 26.5" 28.0"
= Pounds Live Steam Supplied at 25 lb. = 220 °F
= Pounds Water Evaporated from Effect in Question

FIG. 10

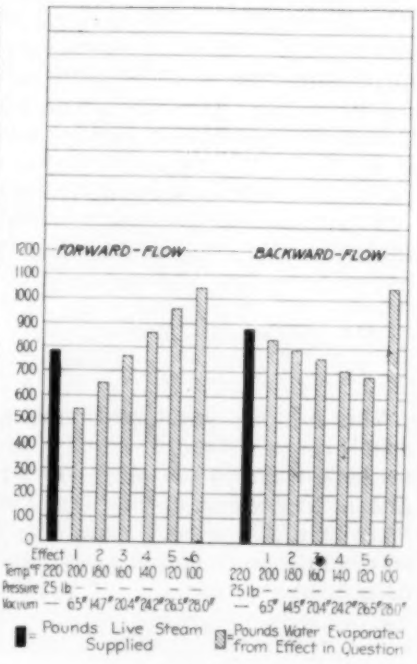
FORWARD-FLOW
BACKWARD-FLOW
Effect 1 2 3 4 5 6
Temp °F 220 200 180 160 140 120 100
Pressure 25 lb —
Vacuum — 6.5" 14.7" 20.4" 24.2" 26.5" 28.0"
25 lb —
220 200 180 160 140 120 100
— 6.5" 14.5" 20.4" 24.2" 26.5" 28.0"
= Pounds Live Steam Supplied
= Pounds Water Evaporated from Effect in Question

FIG. 11

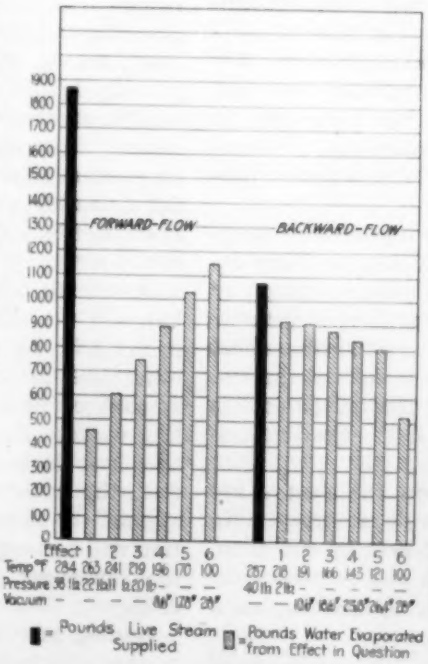
FORWARD-FLOW
BACKWARD-FLOW
Effect 1 2 3 4 5 6
Temp °F 284 263 241 219 196 170 100
Pressure 38 lb 22 lb 11 lb 20 lb —
Vacuum — — — 6.6" 12.8" 28"
1 2 3 4 5 6
257 228 191 166 145 121 100
40 lb 21 lb —
— — 10.4" 18.6" 23.6" 26.4" 28"
= Pounds Live Steam Supplied
= Pounds Water Evaporated from Effect in Question

FIG. 13

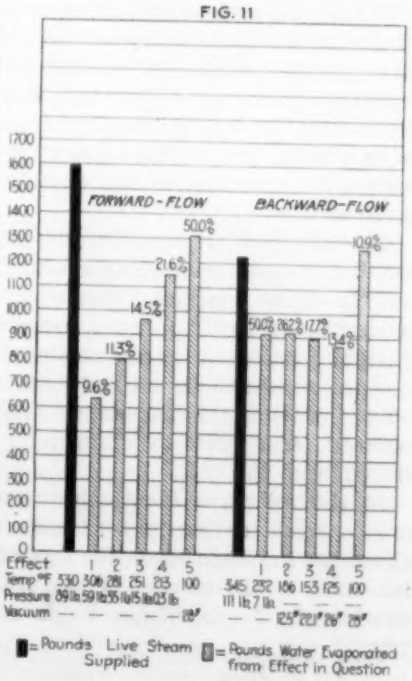

FIG. 16

temperature difference. But in the case of Fig. 4, when the cooler medium is at constant temperature and the warmer medium changes in temperature, as in the example of hot water being cooled by ice or a liquid at boiling point, the mean temperature difference can only be determined in a more complicated manner.

Fig. 5 shows a counter-current conduction example in which the temperature of one medium changes faster than that of the other; such, for instance, as would be the case if the specific heats were different, or if the volumes flowing in unit time were different.

Fig. 6 applies to a parallel-flow exchanger in which the conditions might be as above, with the exception that the fluids flow in the same direction.

Fig. 7 applies to a case in which one fluid changes in temperature by receiving heat from another which does not change in temperature. Such an example would be heating water with steam.

Hausbrand has already developed this subject at some length in his admirable treatise entitled "Evaporation, Condensing, and Cooling Apparatus"; and so it need not be repeated here. Hausbrand has, however, made the subject appear more complex than it really is. Chart 9 is simply Hausbrand's formula simplified. If (a) is the greater temperature difference of exchange and (b) the lesser temperature difference of exchange, then the true mean difference, commonly called the "logarithmic mean," (Lm), may be found by the formula

$$Lm = \frac{a - b}{\log_e \frac{a}{b}}$$

This formula would, of course, not be used for the simple cases of Figs. 1, 2 and 3, of Chart 9. The logarithmic mean in the other cases may vary from the arithmetical mean by amounts ranging from zero to more than 25 per cent, depending on the ratio of the lesser difference of exchange to the greater difference of exchange.[1]

Types of Multiple-Effect Evaporation

We have mentioned herein in a general way the conditions which more or less determine the type of evaporation which shall be followed in a given case. We have not, however, taken into account the fact that there may be varying conditions in the same type of evaporation. In multiple-effect evaporation, for instance, we may follow two distinct and separate procedures.

They are first, forward-flow, the arrangement in which the liquor and steam enter the first effect and the resulting vapor, condensed steam and stronger liquor go toward the last effect; second, backward-flow, or counter-current flow, in which the steam enters the first effect and the resultant vapors and drip flow toward the last effect, while the liquor enters the last effect and is pumped from effect to effect until it emerges concentrated from the first.

In the following illustrative charts the results are only correct to the limit of slide rule accuracy. No allowance has been made for loss of heat by radiation, inasmuch as the amount of this loss can be practically eliminated, if one wishes to do so, by putting on a sufficient insulating covering of the right character. The value of the charts will be found in comparison, and as we have several variables to consider, effort is made to illustrate them in order.

Forward-Flow and Backward-Flow

Suppose we have a solution weighing 5854 pounds, containing 8.54 per cent, or 500 pounds, of solids which have a specific heat 0.5. The liquor enters the system at 32 deg. and we are allowed 20 deg. difference of temperature exchange in each effect. The problem is to concentrate this weak liquor to a 50 per cent solution in six effects. In order to study, as far as possible, one variable at a time, let us assume in this problem that concentration does not materially raise the boiling point. Chart 10 shows that to evaporate this liquor, starting at 32 deg. Fahr., by the forward-flow method, approximately 1490 pounds of live steam are required from the boiler as against 1000 pounds of live steam required by the backward-flow or counter-current method. The next feature to be noticed is that while by the forward-flow method the evaporation increases as the pressure diminishes from effect to effect, in the backward or counter-current flow the evaporation diminishes as the pressure diminishes. In either case the temperature and pressures are the same. In the forward-flow method there is the loss of heat in the extra 490 pounds of condensed steam at 120 deg., equivalent to 43,120 B.t.u., and the loss of heat in the additional 590 pounds of steam at 190 deg. Fahr., equivalent to 651,960 B.t.u., which is lost to the condenser from the last effect. It will be seen that the great loss in heat in the forward-flow is through the condenser; in backward-flow operation much of this heat is utilized in heating up the liquor. In forward-flow operation the cold liquor, instead of being heated by waste heat, so to speak, is heated by live steam.

In the foregoing problem we have assumed that the liquor enters at 32 deg. Fahr. Chart 11 shows the calculated results of a problem in every way identical with the first, with the exception that the liquor enters at 160 deg. Fahr. instead of 32 deg. Fahr. In this case we find that it is more economical of steam to use forward evaporation. Forward evaporation requires 786 pounds of live steam, while backward or counter-current evaporation requires 882 pounds of live steam. Here there is a direct economy of steam in the forward method, to say nothing of the elimination of the necessity of pumping the liquor backward from effect to effect. In forward evaporation the amount of steam saved is not only that which would have been necessary to heat the liquor from 32 deg. to 160 deg., but also the additional saving due to losing less heat in the drip, *i.e.*, as the additional steam required in the other case, after being condensed, carried away a large amount of heat, the saving of this steam also saves this waste. If, however, the evaporation is backward, this heat is lost through the condenser in the steam from the last effect. As we are considering a six-effect system, the saving of live steam by forward-flow operation will be roughly one-sixth of the steam lost through the condenser plus the corresponding saving in the drip.

Having now briefly considered a liquor the concentration of which causes no material rise in the boiling point, let us consider a lquor in which the boiling point

[1] Since writing the above, I find in the November number of the *Journal of American Society of Mechanical Engineers*, a very interesting article by Howard M. Ingham on this subject. He shows an ingenious method of finding the logarithmic mean graphically.

rises markedly on concentration. Chart 12 shows the boiling points of solutions of caustic potash at different concentrations, and Chart 13 illustrates the evaporation of 5854 pounds of an 8.54 per cent caustic potash solution to a 50 per cent solution. In these calculations the specific heat of the caustic potash is taken as 0.5, as in the preceding problems, not because that is correct, but in order not to introduce another variable. This small error makes no fundamental change in the chart. It will be seen that in Chart 13 there are all the general characteristics of Chart 10. The input of steam in forward evaporation has increased nearly 25.5 per cent, while the input for backward evaporation has increased only 6.5 per cent. In forward evaporation the output of steam to the condenser has increased nearly 4.6 per cent, while with backward evaporation it has increased 3.8 per cent. Here, then, there is a large difference in steam input and very little difference in the steam output to the condenser. It will be readily seen from these charts that this difference is mostly due to the increased temperature of the final condensed steam, and the resultant theft of heat.

Temperature Differences

A study of this chart will also show that the other losses of heat in forward evaporation are greater than in backward evaporation. It is not within the scope of this paper to go into the losses of heat by convection to the air, so I will simply confine myself to comparisons, with the general statement that the greater the difference of temperature between similar bodies and the surrounding air the greater will be the loss of heat by convection.

The temperature of the live steam space with forward evaporation is 284 deg., while that of the corresponding space in backward evaporation is 287 deg., a difference of 3 deg. in favor of the former. The temperature of the liquor spaces are 264 deg and 267 deg. respectively, still a difference of 3 deg. in favor of the former. The temperatures of the steam domes are 263 deg. and 218 deg., a difference of 45 deg. in favor of backward evaporation. In the steam spaces of the second effects we have the same temperatures as in the steam dome of the first effects, with a consequent difference of temperature of 45 deg. Table A embodies these comparisons for the whole six effects. It will be seen from the table that there is a total of 6 deg. in favor of forward evaporation and 750 deg. in favor of backward evaporation, or net 744 deg. in favor of the backward evaporation, an average of more than 40 deg. between corresponding effects.

Pressure Differences

Now, as the temperature controls the pressure, it is perfectly logical to place on the same chart the corresponding pressures. While giving the columns of corresponding pressures, it will be noticed that the column of differences is omitted. The reason is obvious. Whereas a substantial excess of pressure on the liquor over that of the atmosphere may be the determining factor as to whether an evaporator can be run efficiently or not, a difference of vacuum practically makes no difference as far as the mechanical operation is concerned. Thus, suppose we had a solution of caustic potash and potassium chloride; a pressure on the caustic effluent might so fill the discharge nozzles with salt, due to the rapid formation of steam at atmospheric pressure, that the operation would not be feasible because of the danger of accidents.

The successful operation of most evaporators requires the use of one or more peep-hole glasses in order that the attendant may be able to watch for foaming tendencies, etc. Now, these sight-glasses, if they are under pressure may either break or crack, and the liquor may blow out into the operator's eyes; there is also the theoretical possibility of the glass itself blowing into his eyes. If, however, a vacuum is maintained, any such breaking or cracking of glass will be inward and the direction of the fluid will be away from the eyes and not toward the eyes.

TABLE A

Effect	Compartments.	Temperature. Forward.	Temperature. Backward.	Temp. Diff. Favoring Forward.	Temp. Diff. Favoring Backward.	Pressures. Forward	Pressures. Backward.
1	A	284	287	3	.....	38 Pressure	40 Pressure
	B	264	267	3	.....	22 Pressure	2 Pressure
	C	263	218	.....	45	22 Pressure	2 Pressure
2	A	263	218	.....	45	22 Pressure	2 Pressure
	B	243	198	.....	45	11 Pressure	10.6 Vacuum
	C	241	191	.....	50	11 Pressure	10.6 Vacuum
3	A	241	191	.....	50	11 Pressure	10.6 Vacuum
	B	221	171	.....	50	2 Pressure	18.6 Vacuum
	C	219	166	.....	53	2 Pressure	18.6 Vacuum
4	A	219	166	.....	53	2 Pressure	18.6 Vaccum
	B	199	146	.....	53	8.6 Vacuum	23.8 Vacuum
	C	196	143	.....	53	8.6 Vacuum	23.8 Vaccum
5	A	196	143	.....	53	8.6 Vacuum	23.8 Vacuum
	B	176	123	.....	53	17.8 Vacuum	26.4 Vacuum
	C	170	121	.....	49	17.8 Vacuum	26.4 Vacuum
6	A	170	121	.....	49	17.8 Vacuum	26.4 Vacuum
	B	150	101	.....	49	28.0 Vacuum	28.0 Vacuum
	C	100	100	.....	0	28.0 Vacuum	28.0 Vacuum
	Totals	....	....	6	750		

A = Heating-steam Space.
B = Liquor Space.
C = Evaporated Steam Space.

In the above caustic potash example, owing to the flatness of the boiling-point curve at the lower concentrations, nothing has been said about the heat of chemical combination with water, or heat of dilution, though this factor was considered in making the calculations. The effect is small, however, so that it does not materially affect the elements of the chart. The object sought was to show the results which must follow an increase in the boiling point during concentration.

Heat of Combination with Water

Let us now consider the effect of the heat of chemical combination of the solids with water. Unfortunately there does not seem to be any good illustration of a case in which there is not a perceptible change of boiling point also brought about by dilution. However, if the preceding illustrations are well understood, there should be no difficulty in understanding this variable. One calculation could be made neglecting the heat of chemical combination and another taking this factor into consideration, but the first would be so far from the truth that a comparison of the two results would not only be of no value but would actually be misleading.

It is well known that there are many substances which dissolve in water with a marked rise in temperature; such, for instance, are sulphuric acid, hydrochloric acid, ammonia, and caustic soda. Now, it is apparent that

if these substances give up heat when added to water, they must likewise absorb heat when separated from water. If this were not so we should have perpetual motion. Now, the data obtainable on this subject is not in the form which lends itself to the calculation of evaporator problems. The first thing, then, for one to do who has a problem in which the heat of chemical combination is an important factor, is to take his data and reconstitute it so that it shall be in convenient form. This may be done much in the same manner as a civil engineer makes a contour map from data of elevations and distances. He connects all points of equal elevations at whatever distances they may happen to be and one is then able to determine the elevation of any particular point by interpolation between successive contours.

Chart 14 gives the relation of boiling point to concentration of caustic soda solutions and Chart 15 is a "contour map" of the heat of dilution of caustic soda solutions expressed in B.t.u. per pound of water added, concentration being changed between known values. Thus, suppose a 40 per cent caustic solution is to be concentrated to a 50 per cent caustic solution; at the intersection of the ordinate 40 and the abscissa 50 we find that the heat of dilution or vice versa, the "heat of concentration," is 210 B.t.u., for every pound of water so evaporated. Thus, in the heat-balance equation for one evaporator effect there might be an equation like this, where x is the weight of water evaporated in that effect:

$$(1865 - x)\ (161) + 1104x + (5439)\ (181) + 210x = (1865)\ (203) + (4259)\ (224) + 1150x$$

It will be seen that after solving this equation for its unknown, the actual amount of "heat of concentration" required may be calculated.

Now, in order that we may see the effects of heat of chemical combination and rise in boiling-temperature combined, let us examine Chart 16. The forward-flow operation is an impossible case as far as practice is concerned, on account of the high pressures we have to contend with. This chart shows the conditions encountered in evaporating an 8.54 per cent caustic soda solution at an original temperature of 160 deg. Fahr., to a 50 per cent solution. It will be seen that in effect No. 2 backward-flow operation, the liberation of steam is greater than in effect No. 1. Heretofore we have had no such abrupt changes. Let us see how this happens. In effect No. 1 there is a high heat of chemical combination, all of which heat is furnished by the latent heat of the live steam, and consequently the steam liberated will be very much less than it would be if there were only a low heat of chemical combination. In the second effect, however, there is a large quantity of condensed steam from the first, cooling approximately 93 deg. This liberates heat enough to raise the evaporation of steam in that effect above the abnormally low value of the first effect. Referring to Chart 15, it will be seen that the heat of combination between 26.1 per cent and 50 per cent concentration is 109 B.t.u. per pound of water evaporated. This same condition applies to forward-flow, but is not so noticeable (see Effect 5), first, because of the large increase in evaporation from effect to effect; second, because the concentration is in that case between the values 21.6 per cent and 50 per cent, instead of between 26.1 per cent and 50 per cent. If, however, the differences are subtracted and the results compared with the preceding charts, the effect of this property will be apparent.

In Chart 11 it was demonstrated that the forward-flow method was more economical of steam when the liquor to be evaporated had been preheated to a considerable extent, viz., 160 deg., in this illustration. But it does not follow that because this is true of liquids in which concentration does not materially raise the boiling point that it is true for those liquids which increase markedly in boiling point on concentration. Thus, Chart 16 shows that backward-flow evaporation is decidedly more economical in steam than the forward method for caustic soda. Here it will be seen that the loss of heat in the drip, due to its high temperature, more than offsets the extra heat lost through the condenser in backward-flow.

Chart 17 is submitted showing the evaporation of the same caustic soda liquor with the conditions the same except that the liquor enters at 32 deg. Here the same rise in evaporation in No. 2 effect backward-flow is

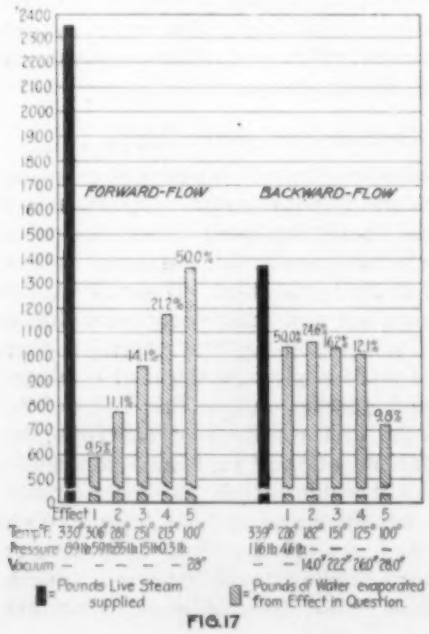

FIG. 17

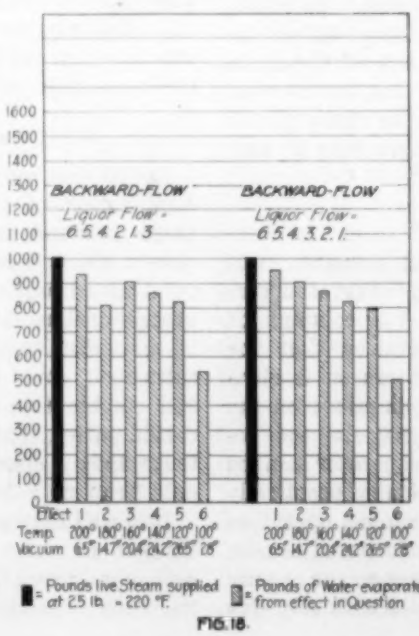
BACKWARD-FLOW
Liquor Flow - 6 5 4 2 1 3
BACKWARD-FLOW
Liquor Flow - 6 5 4 3 2 1
Effect 1 2 3 4 5 6
Temp. 200° 180° 160° 140° 120° 100°
Vacuum 65° 14.7" 20.4" 24.2" 26.5" 28"
= Pounds live Steam supplied at 2.5 lb. = 220 °F.
= Pounds of Water evaporated from effect in Question

FIG. 18.

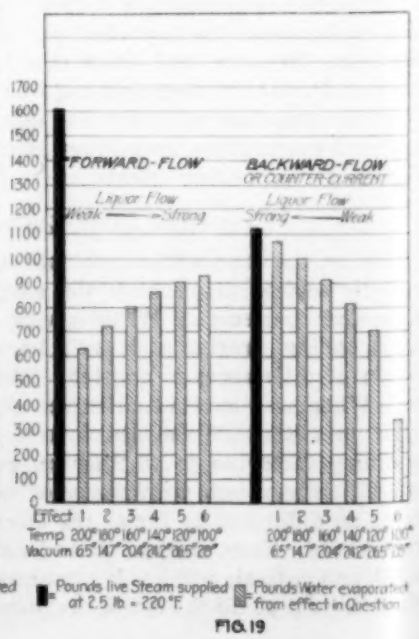
FORWARD-FLOW
Liquor Flow
Weak ——→ Strong
BACKWARD-FLOW
OR COUNTER-CURRENT
Liquor Flow
Strong ——→ Weak
Effect 1 2 3 4 5 6
Temp. 200° 180° 160° 140° 120° 100°
Vacuum 65° 14.7" 20.4" 24.2" 26.5" 28"
= Pounds live Steam supplied at 2.5 lb. = 220 °F.
= Pounds Water evaporated from effect in Question

FIG. 19

apparent, and the decrease in evaporation of No. 5 effect in forward evaporation is equally apparent; as before, the abnormalities are due to the large heat of chemical combination at these points.

In the two last charts the effect of the heat of chemical combination has been illustrated, using a caustic soda solution as an example. In this case the heats of chemical combination are positive. It might be interesting to take an example such as the concentration of ammonium nitrate, in which the heats of dilution with water are negative. The time at the writer's disposal does not permit of his making the necessary charts or calculations, however, and, moreover, we have already considered the subject of heat of chemical combination as fully as it justifiable in a general paper.

Usefulness of the Charts

A study of the charts already submitted will show that not only do they give an idea of the consumption of steam and the mechanical strength required, but that by calculating a chart for the problem in hand one can save in first cost of equipment. For instance, in Chart 16, the condenser for backward-flow operation could not be much smaller than in forward-flow, though the boiler might be smaller. This chart also shows that the piping into the condenser in each case would be nearer the same size. Also, inasmuch as the amount of steam to be condensed is very nearly the same, the amount of water to be handled is much the same.

Comparing the two divisions of Chart 17, one will see that the boiler has to be approximately 70 per cent larger for forward evaporation than for backward evaporation. The condenser in the former has to possess 90 per cent greater capacity than in the latter, and the water supply and equipment must also be greater. The question of water supply alone might decide one in favor of the backward-flow type of evaporation.

Another fact to be observed is that in the backward-flow process the intermediate piping can, as a rule, be approximately of uniform size without waste, while such is not true of the forward-flow method. The former method lends itself better to standardization.

A further study of the subject will show that in the forward-flow method, to a much greater degree than in the backward-flow method, adding an additional effect does not give a proportionate economy of evaporation, and that interest on the investment and maintenance charges may more than offset the economy gained.

Temperature Difference of Exchange

In the foregoing illustrations the temperature difference of 20 deg. Fahr. has been used in each instance. This has been done in order that the point which we wish to consider shall not be obscured by greater variations. It is not, however, meant to intimate that evaporation is always done under 20 deg. difference of exchange, or that 20 deg. is preferable to 10 deg. or 25 deg. The writer is familiar with an evaporator in which the following are the approximate differences of exchange: 8 deg., 9 deg., 15 deg., 20 deg., 26 deg. and 70 deg. This is due to the increase in viscosity of the liquor.

Where a liquor tends to decompose or "gum up" on concentration at high temperatures, and becomes viscous at low temperatures, there is still another procedure which can be followed. Suppose the travel of the liquor is as follows, the effects being numbered serially: 6, 5, 4, 2, 1, 3. Here the liquor gives up its last water at a temperature high enough so that it will remain mobile. A large number of these combinations might be made, and the subject is of enough importance to warrant investigations along this line. The experimental data available at present is not sufficient to warrant submitting many calculations. We have, however, gone far enough in certain experiments to lead us to believe that in spite of the extra complications this method will be useful under certain unusual conditions.

Chart 18 shows that in comparison liquor evaporated backward in the order 6, 5, 4, 3, 2, 1 and backward in the order 6, 5, 4, 2, 1, 3, all the other conditions are alike. It will be seen that the steam consumption is the same in each case, but this is only a coincidence and would vary if the order was changed, the difference of exchange, etc., etc. The coincidence in this case is brought about by recovering some of the heat of the liquor at high temperature from No. 1, which increases the evaporation in 3, 4, 5 and 6, thereby making up for the loss of the decreased evaporation in 1 and 2. It is interesting to note the high evaporation in No. 3, which is due to not having to raise the entering liquor 20 deg., and also due to the giving up of steam by the liquor from No. 1 as in forward evaporation.

If liquor is to be sprayed into a furnace to be evaporated by radiant heat, as described in a previous paper by the author, this backward method, viz., 6, 5, 4, 2, 1, 3, has decided advantages, as the liquor goes in at 160 deg. F. instead of 100 deg. F.

As the thermal coefficient increases with the velocity of the liquor (and therefore also with its mobility) it will be readily seen that by increasing the velocity (or mobility) the heating surface required can be reduced.

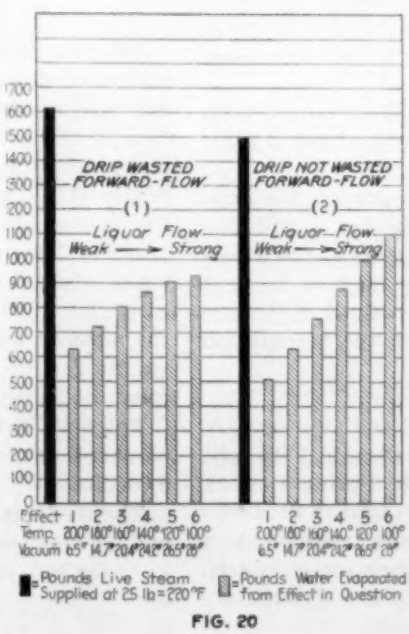
DRIP WASTED FORWARD-FLOW
(1)
Liquor Flow
Weak → Strong
DRIP NOT WASTED FORWARD-FLOW
(2)
Liquor Flow
Weak → Strong
Effect 1 2 3 4 5 6
Temp. 200° 180° 160° 140° 120° 100°
Vacuum 6.5" 14.7" 20.4" 24.2" 26.5" 28"
= Pounds Live Steam Supplied at 25 lb = 220°F
= Pounds Water Evaporated from Effect in Question

FIG. 20

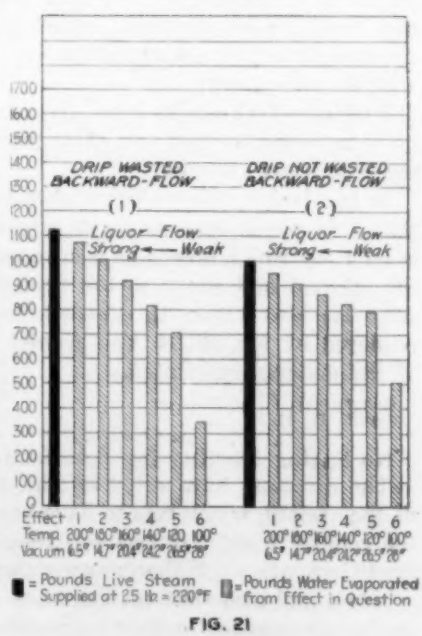
DRIP WASTED BACKWARD-FLOW
(1)
Liquor Flow
Strong ← Weak
DRIP NOT WASTED BACKWARD-FLOW
(2)
Liquor Flow
Strong ← Weak
Effect 1 2 3 4 5 6
Temp. 200° 180° 160° 140° 120° 100°
Vacuum 6.5" 14.7" 20.4" 24.2" 26.5" 28"
= Pounds Live Steam Supplied at 25 lb = 220°F
= Pounds Water Evaporated from Effect in Question

FIG. 21

The velocity or mobility of the liquor is not, however, the only thing to be considered in designing the heating surface of multiple effect evaporators. If air accumulates in the steam space, the effect is the same as reducing the heating surface. It has been assumed for lack of better knowledge on the subject that this effect is in direct proportion to the per cent by volume of air present and the evaporator designer will not go very far wrong if he goes by this rule. The accumulations of air in only one effect may stop the operation of every evaporator in a multiple-effect system. It will thus be seen that evaporators should be so designed that the inlet and outlet for air and its accompanying steam will be so located as to prevent air pockets.

Drip from Evaporators

Many manufacturers waste the condensed steam, that is, they remove the "drip" of each effect separately, and do not try to obtain the available heat therein. This in some cases is justified, though as a general practice the principle is unsound. A justifiable use is in the case of foamy materials where the liquor may be expected to foam over without warning. In this case, if the drips are kept separate, only a portion of the drip liquor would have to be re-evaporated in case of accident, instead of the whole. The efficiency, however, is not as great as when the drip is carried from one effect to another. If the saving due to less re-evaporation is greater than the saving in steam, the method is justifiable. Chart 19 shows the effect on the steam consumption in both forward and backward evaporation by wasting the drip from each effect.

The comparison is more striking if we compare the forward flow with forward flow in Chart 10, and backward flow with backward flow in Chart 10.

Charts 20 and 21 show this comparison, and in the case given for forward evaporation requires 5.6 per cent more steam, and for backward evaporation 12.2 per cent more steam. It is also interesting to note how the wasting of the drip changes the relative evaporations from effect to effect.

This paper does not pretend to go into the matter of steam consumption, the utilization of waste heat in steam to condenser, in drip and hot liquor. Much of this heat can be profitably saved, but as this is not a paper on heat utilization, but on evaporation, this phase will be passed over.

Multiple-effect evaporators should be connected with by-pass valves, so that any effect may be repaired while the others are running.

In conclusion, the writer wishes to express his hope that this paper may suggest subjects for a full discussion, by which means he is sure matters of the greatest interest and profit to the Society may be brought out. He also wishes to acknowledge valued assistance rendered by Mr. W. B. Van Arsdel in the preparation of the material presented.

Brown Co.
Berlin, N. H.

No Spring Meeting for American Chemical Society.—The directors have voted to omit the Spring meeting of the society, which was to have been held in St. Louis the coming April. It was felt that the transportation conditions are such that unnecessary travel should be avoided, and also that the chemists of the country are too busily engaged in meeting war needs.

The Physical Properties of Copper and the Factors by Which They Are Affected*—II

By Paul D. Merica
Division of Metallurgy, U. S. Bureau of Standards

(*Continued from page* 127)

4. Mechanical Properties

In any discussion of the mechanical properties of any material, it must constantly be borne in mind that most of the characteristics determined are more or less dependent upon the method of their determination; the size and shape of test-piece used, the rate of loading, etc., as well as upon the previous mechanical and heat treatment of the material. This is much less true of the elastic properties, the moduli, etc. In general, therefore, it is not possible to assign definite values to these mechanical characteristics; only the range of values given by pure material treated in different ways can be given.

Martens, in an article of great value to those interested in the testing of copper (140), has shown that in the case of copper a variation of testing speed amounting to from 0.5 per cent to 40 per cent elongation per minute causes a difference in the value of the ultimate tensile strength of less than 2 per cent.

Ludwik (139) has, however, shown that for longer periods, the effect of time in testing is quite large. He found that a ½-mm. diameter electrolytic copper wire which sustained a load of 4958 grams for 5 minutes sustained a load of only 4500 grams for 90 hours and one of 3950 grams for 1¼ years.

Martens also showed that although the form of the test piece—ratio of test length to cross section, distance of test length from shoulder of test specimen, etc.—had practically no effect on the values of the ultimate strength and yield point of copper, it exerted a marked effect on the elongation and reduction of area in the tensile test; variations of 15 to 30 per cent were obtained on the same material by varying the ratio

$$\frac{\text{length}}{\text{cross section}}$$ from 1/20 to ½.

(*a*) *Elasticity.*—There is some divergence among the results of determinations of Young's modulus for copper. Values of from 12,100 to 12,300 kg./mm.² (17.2 to 17.5 × 10⁶ lb./sq. in.) have been obtained by careful investigators for electrolytic copper. Determinations by Searle (121) showed a value of 17.6 × 10⁶ lb./sq. in. for drawn and of 18.3 × 10⁶ lb./sq. in. for annealed copper. The temperature coefficient of E at ordinary temperature for copper is given by Wassmuth (125) as $\alpha = 3.59 \times 10^{-4}[E = F(1 + \alpha t)]$ and is negative, *i.e.*, the modulus decreases with rise of temperature. Some values for the moduli at different temperatures are given in Table II.

Poisson's ratio for copper is 0.33 ± 0.01; its temperature coefficient (0 deg. to 150 deg. C.) about 0.00023.

The modulus of torsion for copper as given by Koch and Dannecker (124) is 4240 kg./mm.² (6.15 × 10⁶ lb./sq. in.).

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*Extract from forthcoming Bureau of Standards' circular on copper.

TABLE II—INFLUENCE OF TEMPERATURE ON THE ELASTIC MODULI OF COPPER

Temperature, C°	Mean Modulus of Torsion, Lbs./ Sq. In. (124)	Young's Modulus[1], Lbs./Sq. In. (144)	Young's Modulus[2], Lbs./Sq. In. (144)
0	.....	.....	.....
20	6.02×10^6	17.8×10^6	18.1×10^6
100	5.82×10^6	.....	18.1×10^6
150	.....	.....	.....
200	5.58×10^6	14.3×10^6	15.6×10^6
250	.....	.....	.....
300	4.85×10^6	11.8×10^6	13.5×10^6
350	.....	.....	.....
400	.....	10.1×10^6	.....
500	3.96×10^6	.....	.....
600	.....	.....	.....
800	2.72×10^6	.....	.....
1000	2.10×10^6	.....	.....

[1], [2] determinations on different samples of copper.

The modulus of hydrostatic compression for copper is approximately 12,000 kg./mm.² (20).

(*b*) *Tension test.*—Pure copper may be best normalized by casting, rolling and drawing, followed by annealing for one-half to one hour at about 500 deg. C. and then by slow or quick cooling; after this treatment there is less variation between different samples in the results of the tensile test than in any other condition. The tensile characteristics of copper in this state may be summarized as follows:

Ultimate tensile strength, 35,000 ± 5000 lb./sq.in.
Elastic or proportional limit not determinable.
Elongation in 2 in., 40 to 60 per cent.
Reduction of area, 40 to 60 per cent.

It will be noted that no value is given for the elastic or proportional limits; the usual method of determination of these quantities does not yield any value; *i. e.*, annealed copper yields slightly with the slightest loads which are applied in testing. The values of the moduli given above are determined generally on hot rolled material in which a practical proportionality exists for very small loads.

When copper is cold-worked, rolled or drawn, the

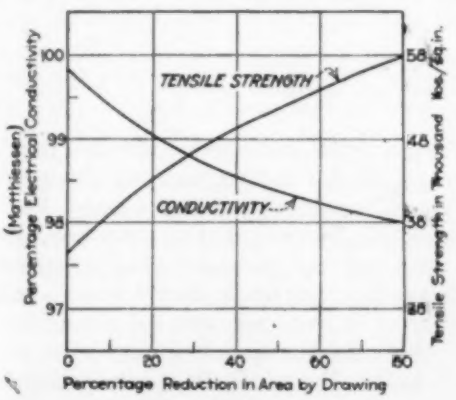


FIG. 15. EFFECT OF COLD WORK ON ULTIMATE TENSILE STRENGTH AND ELECTRICAL CONDUCTIVITY OF PURE COPPER (ADDICKS, 184)

The ultimate tensile strength and the per cent electrical conductivity are plotted as a function of the per cent reduction (area). The wires tested were drawn to No. 12 B. & S. gage from different sizes of annealed copper rod.

hardness and ductility are increased and decreased respectively; at the same time a limit of proportionality makes its appearance. The hardness and ductility of such material depends on the amount of cold work or reduction (rolling or drawing) it has received. Figs. 15 and 16 give a good idea of the changes in these quantities in copper strips with various degrees of cold reduction.

Experiments made at this bureau have shown that modern hard-drawn copper wire is equally affected by drawing throughout the section, and that no hard or exterior skin exists. This has been corroborated by Peirce (141).

A good indication of what tensile test values are to be expected in commercial copper wire, hard, medium,

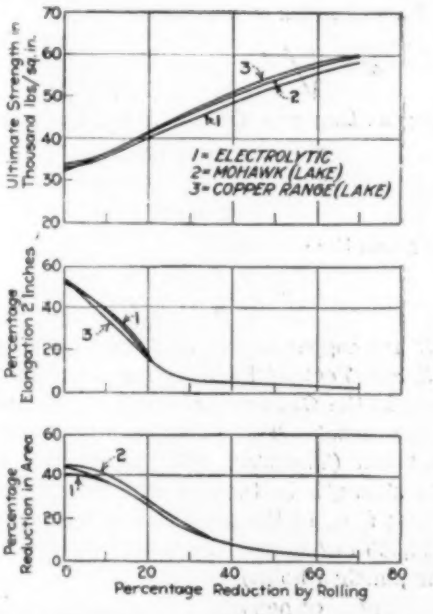


FIG. 16. THE EFFECT OF COLD WORK ON THE MECHANICAL PROPERTIES OF COPPER (TENSILE TEST). (MATTHEWSON & THALHEIMER, 191)

There are plotted the ultimate tensile strength, the elongation in 2-in. and the reduction of area for copper strips rolled to different gages from an annealed strip 0.128 in. in thickness as functions of the percentage reduction of area.

	Per Cent Oxygen	Per Cent Arsenic	Per Cent Silver
Curve 1. Electrolytic copper.....	.071	.000	.0005
Curve 2. Mohawk copper (Lake)....	.052	.096	.069
Curve 3. Copper Range copper (Lake arsenical	.055	.296	.062

drawn and soft may be obtained from the American Society for Testing Materials Specifications.

By increasing the current density and employing a rapidly rotating cathode, Bennet (133) has been able to produce electro-deposited copper of a hardness approaching that of hard-drawn copper; *i. e.*, of a tensile strength of 68,000 lb./sq. in. Some experiments indicating the effect of varying current density upon the mechanical properties of copper were earlier obtained by Von Hüble (137).

Thurston (147) and others give values of the results of the tensile test on copper in different conditions.

TENSILE TEST

Material	Ultimate Strength, Lb./Sq. In.
Cast copper.....	22–36,000
Copper, forged.....	34,000
Copper, bolt.....	36,000
Copper, sheet.....	36,000
Copper, wire.....	62,000

(*c*) *Compression Test.*—Copper of good quality does not fail in the compression test by fracture, it merely yields indefinitely and becomes flattened out.

Thurston (147) states that the resistance of copper

to compression may be calculated (within the limits $e < \frac{1}{2}$) from the formula

$$c = 145{,}000 \sqrt[3]{e}$$

c = resistance in lb./sq. in. of original area
e = fractional compression

This formula holds, according to him, for compressions up to 50 per cent for cylinders of three diameters' length.

(*d*) *Torsion Test.*—Thurston (147) states that copper shafts will break under load when

$$d' = \sqrt[3]{\frac{Fl}{4000}} \text{ or } d' = \sqrt[3]{\frac{Fl}{8000}}$$

according as they are of cast or worked copper.

d' = diameter in inches
F = torsional moment
l = lever arm

He also gives the equation

$$d' = \sqrt[3]{\frac{5.1\,Fl}{S'}}$$

where S' for copper should be from 15,000 to 30,000 lb.

(*e*) *Shear Test.*—The shearing stresses for copper are given in the *Ordnance Manual* of the United States War Department. The shearing resistance of copper may be taken (Thurston, 147) as equal to that of the ultimate strength in tension and subject to the same variations; *i. e.*, in the annealed or cast condition, 22,000 to 36,000 lb./sq. in. The work done in shearing copper (for punched holes) is (147)

$W = 96{,}000\,dt$
W = work in foot pounds
d = diameter of hole
t = thickness of plate or sheet

(*f*) *Transverse Bending Test.*—Thurston (147) gives the modulus of rupture as varying between 20,000 and 40,000 lb./sq. in.

(*g*) *Hardness Test.*—It is well known that this property is expressed in many different ways, many of them quite arbitrary.

On the Mohs or mineralogic scale copper has a hardness of from 2.5 to 3. Tammann (146) states that soft and hard copper gave the same values of sclerometer hardness. A hardened steel needle (Martens sclerometer) gave a scratch of 0.014 to 0.016 mm. width when loaded with 10 grams, and one of 0.022 to 0.027 mm. when loaded with 17 grams.

The scleroscope hardness of annealed copper varies from 6 to 7 (universal hammer), whereas that of hard copper (cold reduction of 66 per cent) varies from 22 to 24 (186).

The Brinell hardness of annealed or cast copper is 35 ± 5 (500-kg. load, 10-mm. ball); when hardened by cold work the ball hardness thus defined may become as high as 100. Guillet (189) has determined the ball hardness and the tensile strength of copper in various states of hardness, produced by pressing annealed copper in a steel die to different thicknesses. His results are given in Table III.

TABLE III—BRINELL HARDNESS OF COPPER

Per Cent Cold Reduction of Section	Brinell Hardness Numeral, 500 Kg.		Tensile Strength, Lb./Sq. In.	Elongation in 11 Cm. per Cent.
	10 Mm. Ball	5 Mm. Ball		
Annealed 0.....	42	50	33 600	46
10.....	70	74	36 000	24
20.....	81	81	40 000	13
30.....	86	90	45 000	5
40.....	94	92	47 800	4.5
50.....	96	95	52 600	4.2

It is seen that that ratio of $\frac{\text{tensile strength}}{\text{Brinell hardness}}$ is variable with the hardness of the copper.

(*h*) *Impact Test.*—Impact tests of copper have been so few that no final or typical values could be chosen from the data. Baucke (132) has carried out a number of tests according to Frémont, using rectangular bars 10 x 10 mm., with a sharp saw-notch of 3 mm. depth; the specific impact work was measured. Some of the results are given in Table IV. He compares the tensile strength, reduction of area and elongation (in (?) in.). For certain special brands carrying arsenic, nickel and iron (98.5 to 99.9 per cent copper), giving tensile strengths of from 20 to 31 kg./mm.² (28,400 to 44,000 lb. / sq. in.), elongations of from 40 to 50 per cent, reductions of area of from 50 to 77 per cent, the specific impact work varied from 10 to 33 kg. M. (72.4 to 239 ft. lb.) in longitudinally cut specimens and from 9 to 31 in transverse specimens. For ordinary brands, oxygen content 0.11 to 0.06 per cent, copper 99.5 to 99.8 per cent, having tensile strengths of from 21 to 24 kg./mm.² (30,000 to 34,000 lb. / sq. in.), elongations of from 30 to 47 per cent, reductions of area from 33 to 70 per cent, the specific impact work varied from 10 to 15 kgM. (72.4 to 109 ft. lb.) in longitudinally cut specimens and from 3 to 11 kgM. (21.6 to 79.5 ft. lb.) in transverse specimens.

TABLE IV—IMPACT TESTS OF COPPER. BAUCKE (132).

Chemical Composition. Impurities in 0.01 per Cent										Specific Impact Work, (1)		
Anti-mony	Tin	Arsenic	Lead	Bis-muth	Iron	Zinc	Nickel	Man-ganese	Oxy-gen	Per Cent Copper	Kg. M.	
Commercial fire-box plates											*L*	*T*
..	3	33	2	<1	11	1	..	..	6	99.44	11.0	10.5
..	..	..	1	1	2	..	9	..	8	99.80	11.0	5.5
..	..	..	11	..	4	12	..	..	8	99.57	9.0	8.1
..	..	1	3	1	5	..	23	..	10	99.57	10.9	3.1
..	2	..	5	1	3	22	10	..	10	99.48	10.8	9.1
..	1	..	..	<1	2	..	1	..	11	99.81	10.4	5.3
..	..	1	5	..	5	9	22	..	11	99.47	10.5	....
1	..	..	35	1	1	..	2	..	11	99.50	8.3	5.3
..	..	..	2	<1	19	1	..	..	11	99.66	13.8	10.1
..	1	..	3	<1	2	..	1	1	11	99.81	19.0	6.4
..	..	14	7	..	4	14	..	..	12	99.50	8.3	5.3
Special copper (Heckmann) for plates												
..	201	..	..	..	..	45	..	..	..	..	28.6	26
..	82	..	..	..	..	40	..	..	..	..	28	
..	..	7	..	..	3	..	4	..	..	..	18	

(1)—Baucke gives S. I. W. in kilos, but it is assumed that he means kilogram-meters.
L = longitudinally-taken specimens.
T = transversely-taken specimens.

(*i*) *Fatigue or Alternating Stress Test.*—Very few data of this sort are available. A few tests have been carried out by Johnson (259, 261), the results of which will be given in Table V. in a subsequent article; he used the Arnold type of testing machine, which applies very high fiber stresses above the elastic limit.

5. MISCELLANEOUS

(*a*) *Density.*—The density of pure copper, rolled, forged or drawn and afterward annealed, may be taken as 8.89 at 20 deg. C. This value was accepted by the

International Electrotechnical Commission in 1913. Samples of high conductivity copper will vary (149) usually between 8.87 and 8.91; in some cases samples have shown densities as high at 8.94 and as low as 8.83. Variations in density may be due to microscopic flaws or seams (low density) or to the variation in the percentage of oxygen present (0.03 per cent oxygen lowers the density by about 0.01). The density of cast copper will be about 8.89 when no blowholes are present; otherwise lower densities will be found.

According to experiments by G. L. Heath (148) there is but an extremely small difference between the density of hard-drawn and hard-drawn annealed copper. No difference in density is detected between the two high grades of copper. The mean density of 10 hard-drawn samples of wire was 8.898; after these samples had been annealed their mean density was 8.900, showing an increase of density upon annealing of approximately 0.02 per cent. Similar values of the increase in density of hard copper upon annealing have been found also by Gewecke (187) and by Kahlbaum-Sturm (150); these ranged from 0.001 to 0.10 per cent, and averaged about 0.02 per cent.

(To be Continued)

Intensive Toluol Production—II.

Proposed Improvements in the Concentrating and Refining Process

By Frank E. Lichtenthaeler

CRUDE light oil containing benzol, toluol and other less important constituents is obtained by subjecting the vapor-gas mixtures of these substances to the absorbing action of a higher boiling medium, with subsequent heat treatment of the absorbing medium to remove the recovered volatile portion. This is commonly known as the absorbing and stripping process for toluol recovery. In a previous article[1] dealing with this process we have recommended the use of tar as the most suitable absorbing medium, at the same time offering improved procedure and plant, broadly conceived, in the hope of contributing toward a quick and permanent relief of the existing critical situation in respect to the deplorably short supply of toluol.

Present Concentrating and Refining Process

The usually accepted method of working up the crude light oil to produce "toluol pure" has been described at length in other publications, of which the recent and interesting report of the United States Bureau of Standards is mentioned in the way of reference. The crude light oil is roughly separated by distillation into three fractions, known as crude benzol, crude toluol and crude solvent naphtha, by means of a periodic still having a short rectifying column. The crude toluol fraction is treated chemically with sulphuric acid to remove olefines and other unsaturated bodies, washed with water, neutralized with dilute alkali solution and again washed with water to remove any excess of alkali. The olefine-free toluol fraction is finally distilled in a periodic rectifying still, using a tall column of standard bell-and-seal type with external reflux condenser or dephlegmator. In the latter operation the finished toluol-pure fraction constitutes the middle portion or heart of the run. These related operations, or their equivalent, we have termed the concentrating and refining process.

Evolution of Present Procedure

In the hope of developing a better perspective in regard to the toluol concentrating and refining process, it seems desirable to review briefly the evolution of the above mentioned procedure. Contrary to the older and more highly developed European chemical practice, there has been a marked tendency in America to employ inadequate apparatus for carrying out the initial steps of a process, without realizing that the imperfect result, directly attributable thereto, predetermines the necessity of more elaborate and difficult refining operations at the end. Our synthetic chemical industry is replete with striking illustrations of this fallacious practice, although there are exceptions pointing to real progress due to more logical conceptions and a willingness to make judicious expenditures for well adapted plant for preliminary work in order to simplify succeeding operations.

Naturally, the development of light-oil concentrating and refining has followed a similar channel. Formerly the crude light oil was distilled and redistilled in plain stills, without columns or dephlegmators, and extremely rough concentrations were thus effected. Consequently the tax on the chemical washing operation was heavy and the shrinkage at this point considerable. The rectifying operation was carried out in antiquated types of column stills, the supposed advantage being that they were cheap to build. Two or three distillations were thus required, the excessive and accumulative cost of which long escaped attention. In course of time it occurred to some venturesome innovator to try a fractionating column in connection with the initial distilling operation. The column, if we may dignify it as such, consisted of an upright piece of pipe filled with coke or quartz pebbles. A decided improvement resulted, and all those divining the secret immediately did exactly likewise and profited accordingly. Another lapse of time and the idea suggested by the pebble column again overcame inertia, with the result that the present short cap column and dephlegmator were applied, notwithstanding the radical departure this step involved. The results were surprisingly good, which brings the history to date where progress once more pauses to further demonstrate the fallacy of leaving well enough alone.

Analogous Development of Wood Chemical Practice

The development of the wood chemical industry in America affords an interesting analogy to the above. Crude methods and apparatus have been adhered to with astonishing tenacity worthy of a better cause. Consider for example our time-honored practice of producing 82 per cent crude wood alcohol, yellow with tar, loaded with the most baffling impurities, and requiring elaborate and repeated treatments by distillation and chemicals to eventually yield a semi-refined alcohol. The magic of 82 per cent crude rests solely in the fact that this was the highest concentration attainable with the old-fashioned Burcey pan stills even now in use at some of the plants. This has set the pace for present and future generations, with here and there an isolated exception, notwithstanding the fact that our Canadian neighbors have long since discovered that by continuous concentration of the neutralized wood liquor

[1] This Journal, Feb. 1, 1918, pp. 144-152.

in an efficient column still of modern design the tar and oily impurities can be eliminated completely at the start, distilling over a water-white highly concentrated product, which may be sold directly as wood alcohol or very easily refined to pure methyl alcohol 99½ per cent strong containing below one-eighth of 1 per cent of acetone.

This nearly parallel case is referred to as suggesting the desirability of applying to the concentrating and refining of crude light oils certain definite improvements in distillation methods and apparatus which have contributed so much toward better economy in the wood chemical field. A comprehensive system of concentrating and refining volatile liquids by distillation has been developed, based on our experience and observations extending over many years; a system that has been thoroughly and successfully tried out not only in the wood chemical field, but in various other instances, always involving a crude material of complicated composition from which it is desired to isolate one or more volatile components in a highly refined condition. This system has, as its foundation, the premise that the concentrating operation, *i. e.*, the isolation of fractions in which the desired components predominate, by the very character of the work to be performed, demands apparatus of the highest practical efficiency. Thus only can objectionable impurities be removed that otherwise persist as an unnecessary burden through all succeeding operations. Needless labor and operating expense thus eliminated at the start represent a very substantial economy, as compared to the more usual practice, especially in the case where valuable materials are to be handled on an enormous scale. Could there be a more opportune occasion for the application of this obviously more logical and economical procedure than presented by the unsatisfied demands for an unlimited supply of toluol for war and after-war needs?

Other important benefits to be derived from the use of efficient concentrating stills for the preliminary fractionation of crude light oil may be enumerated. Olefines are more completely removed from the principal concentrate, crude toluol, so that the latter requires correspondingly less sulphuric acid in the chemical treatment. Furthermore, these otherwise lost olefines, together with separable paraffines, become readily available for gas enrichment. High concentration obtainable in respect to toluol means less benzol and solvent naphtha to be removed in the final rectifying operation, with consequent higher yield of toluol in one operation. It directly follows that the final rectifying still, having less work to perform, may be correspondingly smaller. The reduced steam consumption alone, due to economies made possible by continuous operation, affords ample justification of the suggested procedure.

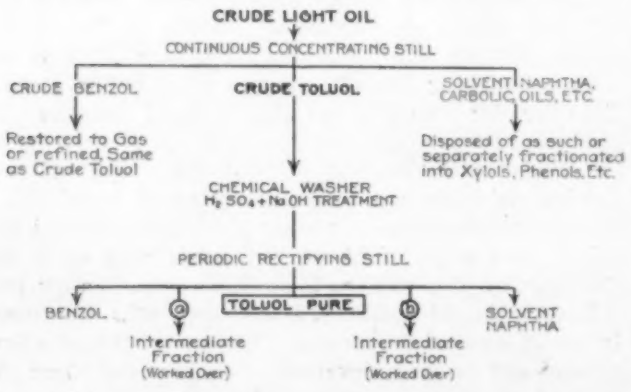


FIG. 7. LUMMUS SYSTEM OF "LIGHT OIL" CONCENTRATING AND REFINING

Light-Oil Concentrating and Refining

The Lummus system of light-oil concentrating and refining, as illustrated diagrammatically in Fig. 7, is described briefly as follows:

The crude light oil is handled directly in an efficient continuous concentrating still, which effects a simultaneous separation into three concentrates, which we will term crude benzol, crude toluol and solvent naphtha. The crude toluol fraction, containing all the toluol present in the original light oil, together with a small percentage of lower and higher boiling impurities, is next treated chemically with sulphuric acid to remove olefines and other unsaturated bodies, washed with water to remove acid left in suspension, then with dilute caustic soda solution to neutralize the remaining traces of acid, and finally again washed with water to remove any excess of caustic soda. The neutral crude toluol is then fractionated in an efficient periodic rectifying still, the following fractions being collected in order of their increasing boiling points: benzol, intermediate fraction *a*, toluol-pure, intermediate fraction *b* and solvent naphtha. Toluol-pure, forming the main part of the run, is here turned out in finished condition, ready for shipment to the munitions factories, and our main purpose is thus accomplished.

Intermediate fractions *a* and *b*, both containing toluol, are run into the same tank and re-distilled after sufficient quantity has been accumulated for a full still charge, using the same periodic rectifying still mentioned above. The combined benzol fractions, resulting from both the continuous and periodic still operations, may be restored to the illuminating gas, or eventually may be used in the manufacture of explosives. Chemical treatment and final rectifying must be applied to this unfinished material to yield benzol-pure. These operations may be carried out in exactly the same manner as described in connection with crude toluol. The same apparatus may be used for producing benzol-pure provided, of course, that sufficient capacity has been furnished with this end in view.

Assuming that tar has been used as the absorbing medium, as suggested in our previous article, the solvent naphtha fractions referred to above would contain carbolic oils as well as xylols. In this case it may ultimately prove desirable to work up the carbolic oils into phenol for picric acid, thus requiring additional apparatus especially designed for the purpose. As this is a separate undertaking from that of producing toluol, we will not stop at this time to describe in detail the methods and apparatus for working up these side products. The solvent naphtha fractions may be subjected to cracking processes and thus caused to yield additional benzol and toluol in substantial amounts. It was first pointed out by Dr. W. F. Rittman that the mixture of higher boiling aromatic compounds constitutes a highly favorable raw material for producing toluol by cracking either in tubes or furnaces, and as recently confirmed and demonstrated in a timely reminder of

this important possibility, some millions of gallons of toluol could thus be added to the supply.[1]

It will be observed that the concentrating and refining process recommended is practically the same as that commonly followed, except that a continuous concentrating still is employed for the preliminary fractionation in place of the short column periodic still usually mentioned. We advocate this radical change

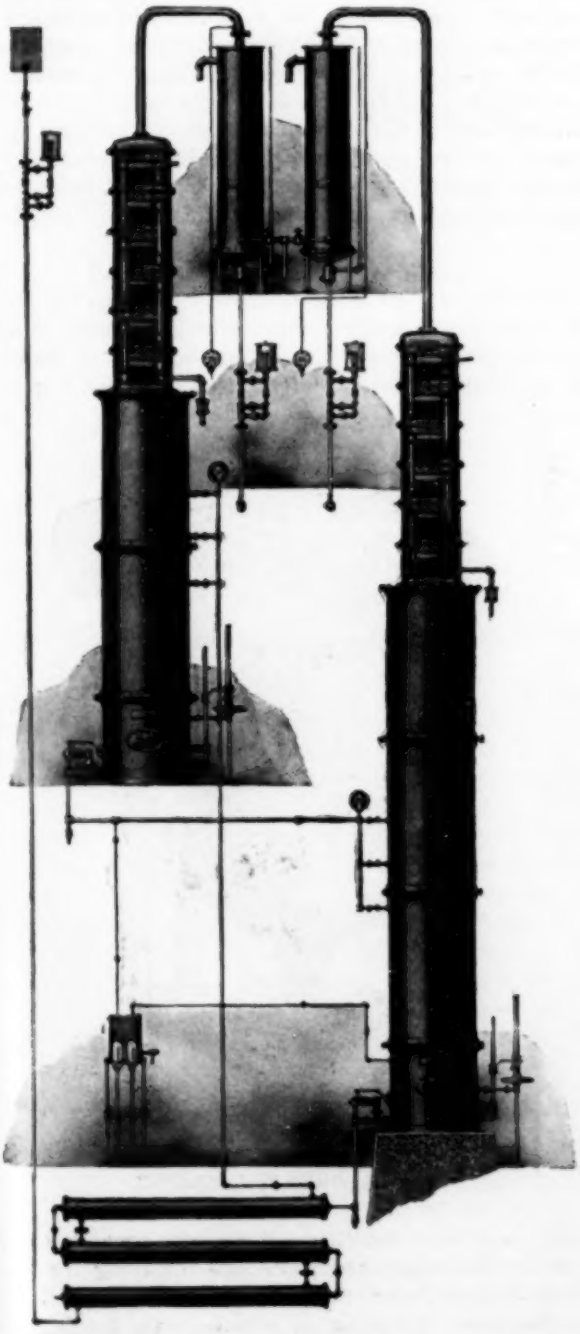


FIG. 8. LUMMUS DOUBLE-COLUMN CONTINUOUS CONCENTRATOR

in order to gain the important advantages referred to in paragraphs six and seven above, none of which is possible with any other type of apparatus. Furthermore, in the final rectifying operation we employ an improved design of fractionating column capable of effecting sharper separations, thus increasing the initial yield of toluol-pure, at the same time materially reducing the quantity of intermediate fractions, which require working over with consequent duplication of expense.

[1] Egloff, Jour. Ind. & Eng. Chem., Vol. 10, No. 1.

Double Column Continuous Concentrator

The continuous concentrating still, recommended for the preliminary fractionation of the crude light oil, is illustrated in Fig. 8. This is known as the Lummus double-column continuous concentrator, designed for turning out simultaneously the three concentrates mentioned above. This apparatus is of iron construction throughout, and especially adapted to conditions obtaining in the case under consideration. That is to say, while the type of still is one that we have applied broadly to various concentrating problems, the specific apparatus shown is a recent development, designed and proportioned throughout for continuous fractionation of crude light oil into crude benzol, crude toluol and solvent naphtha. Note that both columns include the system of internal refluxing, which, in our opinion, represents the highest development of the art, affording the best means for effecting sharp separations of mixed volatile liquids, with high economy in respect to steam and water consumption. This system will be described more in detail in a later paragraph. Both distilling columns are provided in their bottom chambers with suitable high-pressure steam heating coils and perforated sparger pipes for injecting live steam, although the use of the latter is not always necessary. A heat interchanger is used for economizing the waste heat of the residual solvent naphtha fraction discharged from the bottom of the second column, and ample control of conditions is provided for in the way of column pressure regulators, recording thermometers for charting the boiling points of distillates, dial thermometers for the various feed liquors, feed and product gages for measuring the rate of flow of both feed and distillates, also special testers for checking the liquor discharged from the first into the second column and for indicating the composition of the residual solvent naphtha fraction.

Referring to Fig. 8, the crude light oil flows by gravity into a small constant-head float tank from a suitable elevated storage tank. The rate of flow of the crude light oil, fed continuously to the apparatus, is controlled by a suitable valve and accurately measured by a feed gage, as shown at upper left-hand corner. The crude light oil next is heated in heat interchanger, shown at bottom of cut, by means of the waste heat of the solvent naphtha fraction and is then admitted to column No. 1 through one of the manifolded inlet connections. The temperature of the inflowing feed is indicated by a dial thermometer. The conditions in column No. 1 in respect to the amount of heat supplied and the temperature maintained throughout the internal reflux system are adjusted to cause the vaporization and concentration of the so-called crude benzol fraction. This fraction, comprising benzol and all lower boiling components—but no toluol—is condensed and cooled in a final condenser from which it flows to its storage tank, the rate of flow and boiling point being indicated by a product gage and recording thermometer shown directly below the condenser.

The residual liquor emerges from the bottom chamber of column No. 1 and crosses over to column No. 2,

being admitted through one of the manifolded inlet connections at a fixed temperature indicated by a dial thermometer. In this column conditions in respect to heat and internal refluxing are adjusted to effect vaporization and maximum concentration of the crude toluol fraction, which is condensed and cooled in its respective final condenser from which it in turn flows to its storage tank, the rate of flow and boiling point also being indicated by a product gage and recording thermometer, as shown. The crude toluol fraction comprises all of the toluol present in the original crude light oil, together with small percentages of benzol, olefines, paraffins and traces of other components boiling slightly higher than toluol.

The residual liquor, known as solvent naphtha, and comprising components of higher boiling point than toluol, flows from the bottom chamber of the second column through the heat interchanger previously referred to and thence to its storage tank. It will be noted that the three products are turned out simultaneously and at a continuous uniform rate throughout 24 hours of the day. There is no time lost for still charging and dumping, nor for heating and cooling the charge—these being the inherent disadvantages of the present periodic or batch concentrating stills.

Internal Reflux System

A brief description of the Lummus internal reflux system may not be out of place at this point of our discussion, together with a statement of our reasons for applying this system to the concentration of crude light oil fractions. All other continuous or periodic column stills employ what is known as an external reflux condenser or dephlegmator, the purpose of which is to flood the column chambers with condensate of reasonably high purity, this being favorable to increasing the purity of the final vapors passing from the top of the column. Unfortunately, by returning this condensate to the top chamber only, this very desirable effect is largely confined to the few uppermost decks of the column with the direct result that an excessive amount of condensate must be returned, which requires a correspondingly excessive amount of steam for re-evaporation, as well as water for condensation. The Lummus patented internal reflux system consists of a number of small reflux condensers or dephlegmators distributed throughout the entire upper part of the column, so that each tray of bells and seals is provided with its individual dephlegmator. By thus distributing the work of refluxing, not only are much sharper fractionations made possible, but this may be accomplished with very much less steam and condenser water. The requisite column construction, although slightly more elaborate than that applying to the externally placed dephlegmator, is eminently practical, and after sixteen years of development has naturally been reduced to routine practice with us, so that the ultimate cost is practically the same as that applying to the somewhat more simple though far less efficient external dephlegmator. The several water-cooled tube bundles, constituting our internal reflux system, are all removable intact for cleaning, testing and replacement of worn out tubes. In fact, this type of apparatus is far more accessible than the less modern external dephlegmator, while so far as operation is concerned, adjustment and control of conditions are accomplished more conveniently and with far greater precision. The water passes in series through all of the internal dephlegmators, so that there is but one water control valve and one overflow requiring attention. The amount of water required by this system for refluxing is frequently as low as one-half that employed by the external reflux condenser, and we have actual tests on record indicating steam consumptions of 35 to 50 per cent of that required by the less efficient apparatus referred to. At the same time, due to the very sharp separations effected, it is possible to greatly reduce the percentage of higher and lower boiling impurities in the main concentrate, namely, crude toluol, thus materially lessening the difficulty and cost of the subsequent refining operations. Other impurities which, due to proximity of boiling points, are generally regarded as inseparable, may sometimes be eliminated by this type of still head.

Chemical Treating Process

Proceeding next to the subject of chemical treatment, it seems that this must remain, for the present at least, a rather clumsy makeshift, obtruding itself in the midst of an otherwise fairly well ordered process. For sheer

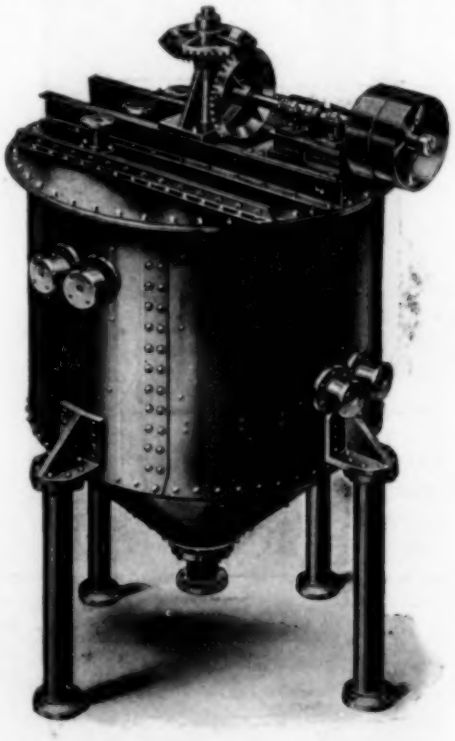


FIG. 9. CHEMICAL WASHER

lack of a worthy substitute, it becomes necessary to adhere to the established procedure involving the treatment of large batches of crude toluol with small doses of chemicals, imitating on a large scale the laborious separatory-funnel laboratory method of adding, shaking, settling, drawing off, and so on, repeatedly. Olefines and similar unsaturated compounds, because of proximity of boiling points or due possibly to the formation of constant boiling-point mixtures, have not been separated from toluol by distillation alone. Therefore sulphuric acid is employed to form water-soluble sulphonates which then may be removed by settling and separation of the acid layer, followed by neutralization with alkali together with thorough washings with

water. These operations are carried out in the so-called washer, illustrated in Fig. 9. The washers are lead-lined for the sulphuric acid treatment and of plain steel construction for the alkaline treatment. They are closed tight, with removable cover sections to minimize evaporation losses, and provided with high-speed screw agitators and cylinders to cause thorough mixing. The acid washer has lead cooling coils suspended just below the liquor level to remove the heat generated by the

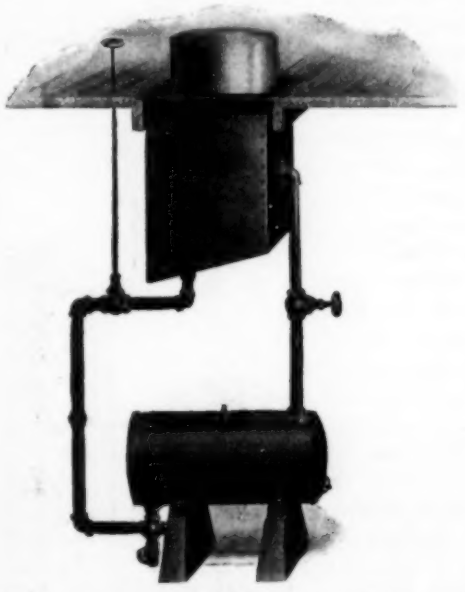


FIG. 10A. ONE-DRUM PATENT AUTOMATIC DISSOLVER

acid reaction. The balance of equipment for the chemical treatment consists of a lead-lined tank for acid storage and a plain steel tank for caustic soda solution.

The handling and dissolving of caustic soda is always a disagreeable and even dangerous operation. Actual first-hand experience with this troublesome material some years ago has since led us to devise dissolving and handling apparatus that seems worthy of mention in the present connection because it so effectually eliminates the usual difficulties. Fig. 10 illustrates two standard sizes of our dissolver as now extensively employed for dissolving whole cakes of caustic soda. Solution is effected rapidly and automatically by the positive circulation caused by the difference in gravity between the heavy solution and the much lighter cold water with which the outfit is at first charged. The whole caustic cakes are supported by a heavy cast iron grid in the upper part of the tank; the system is filled with water, so as to partially submerge the cakes, and solution then proceeds to completion without aid of heat or stirring. For very heavy solutions a thermo-syphon is placed in the circulation riser for heating the water to increase its solvency. This, however, is not necessary for producing 30 deg. B. and weaker solutions.

These dissolvers are made in sizes to handle one, two, four, five and ten whole cakes at a time. We also have devised a very convenient form of lifting tongs, capable of gripping the bare caustic cake as it lies horizontally on the floor and permitting the cake, upon lifting, to swing into a vertical position ready for lowering into the dissolver. Thus the entire operation may be carried out in safety without touching or breaking the original cake, with entire saving of steam or power for stirring, and without labor or attendance except as required to charge the dissolver at the start. We have come to consider this simple equipment as forming an essential part of any operation involving the use of considerable quantities of caustic alkali.

Refining Stills

The final rectifying or refining operation is of necessity a periodic or batch process. If a reasonably uniform crude toluol could be produced readily, this depending in turn upon uniformity of composition of the crude light oils, notwithstanding their widely different sources, then it would be feasible to employ a continuous refining still with all the advantages in respect to economy attending continuous operation. If a prediction may be based on parallel development in allied fields, it seems reasonable to look forward to continuous benzol and toluol refining as a highly desirable ultimate aim made possible by eventual standardization of preliminary methods of production with consequent control of light-oil composition. Until this more advanced status materializes, a conservative policy seems to require adherence to the batch refining process. The latter lends itself to a great variety of changing conditions without seriously affecting the ultimate product, toluol-pure. Mistakes made in previous operations can generally be remedied through the medium of a final periodic distillation. The continuous still, on the contrary, is rather inflexible, demanding, especially in the case of a refining operation, fixed conditions which cannot yet be counted upon.

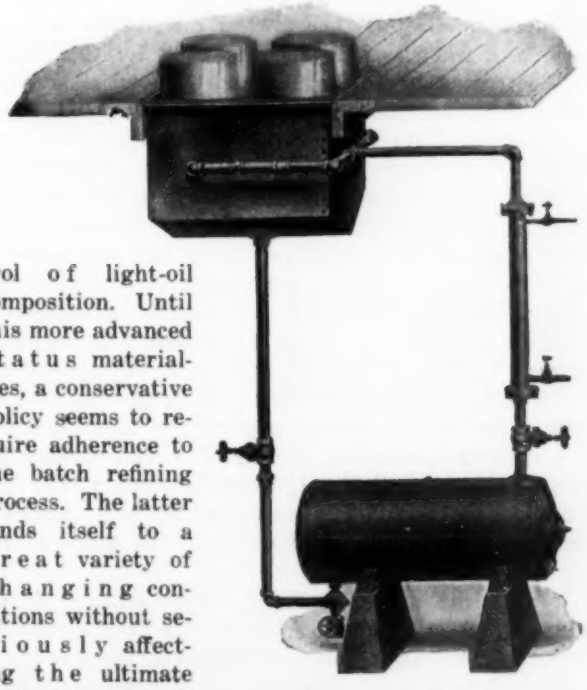


FIG. 10B. FOUR-DRUM PATENT AUTOMATIC DISSOLVER WITH THERMO SYPHON

The type of periodic or batch still usually employed in the toluol refining operation is illustrated in Fig. 11. This apparatus is distinguished by having the familiar external reflux condenser or dephlegmator. The column is of the well known boiling-cap or bell-and-seal type, constructed throughout of cast iron and steel. This standard type of still is furnished by all still manufacturers, our particular make claiming attention only in respect to improved results that may be due to our use of a novel form of slotted vaporizing cap which insures very thorough contact between ascending vapor

and descending liquor within the column, as well as to other minor details of construction which add to the life of the apparatus and the convenience attending its operation.

In this connection it is desired to call attention to an apparently wrong impression that appears to exist in respect to column construction as required for toluol refining. We have noted various detailed descriptions of columns for the purpose, none of which seems to grasp the significant underlying facts which determine the real merit of one type as compared to another. There are, for instance, specific allusions to mysterious column dimensions, such as 3 ft. 3 in. in diameter, with chambers 12 in. to 14 in. in height, conveying the incorrect idea that upon such minor points depend the satisfactory production of toluol. Another article explains that a column for one purpose is required to have serrated caps or bells, and for another purpose the serrations are omitted, but without giving reasons. These statements are mentioned not for their intrinsic importance, which may not be great, but merely as they represent the general tone of the published information in question. Details are always interesting and may be helpful when stated parenthetically for the purpose of illustrating broad discussion. Our criticism refers to the undue emphasis laid upon unessential details and non-representative apparatus types, leading to the inference that classic examples have been set forth, arrived at by a careful exclusion of all but the best. All this may be explained, possibly on the grounds of blind description of accidental apparatus that happened to come within the limited experience of the particular writer. The unfortunate result is that the misleading information, coming from supposedly authoritative sources, inclines the uninformed buyer of apparatus to insist on the absurd and non-essential specifications exactly as published, and the opportunity to educate him to a sane understanding of important determining factors is completely lost. Ignorance, which might have been partly dispelled, has been more firmly grounded by thus setting forth superficialities in the guise of real knowledge.

It must be made clearer to those concerned that column and still details are subject to considerable variation. We have employed column sections as low as 4 in. in height with good results. We regularly make them 6 in., 8 in. or 10 in. high, or higher, as required to obtain a proper balance between desired capacity and economical construction, uninfluenced generally by the particular material to be treated. Serrated caps are always better than plain dipping bells. The horizontally slotted cap, as originated by us, offers certain advantages in respect to release of bubbles at a uniform depth of liquid, more thorough vapor liquor contact and low column back pressure. We hardly could claim that some one's else column would not produce toluol because our patent caps were not used. It should be realized that these differences are mainly of degree, just as one type of gun may offer certain advantages over another, without excluding either type. Would it not, therefore, have been the part of wisdom to leave details of construction to reliable builders of the necessary apparatus, placing emphasis instead upon matters of broader meaning, so that the uninitiated might be helped to a reasonably comprehensive understanding of the tools available for performing the task confronting him. As matters now stand, it will be decided quite naturally that the slightest variation from narrow and rather obsolete specifications, already published, of necessity rejects available equipment which in reality may be far superior to the narrowly defined examples set forth. We are already encountering and endeavoring to combat the retarding effects of this ill-advised yet influential information. If some manufacturer had arranged a campaign solely to favor his particular type of apparatus, the incidental propaganda could not have been more skillfully planned and disseminated. In this case, undoubtedly with the most praiseworthy intentions, the same results are brought about and at a time when intelligent conceptions are badly needed and ill-founded prejudices become serious obstacles in the way of wisely directed co-operative action.

Periodic Toluol Refining Still

Returning to the subject of refining stills, Fig. 12 illustrates the Lummus periodic refining still with patented internal reflux system. We especially recommend this still for toluol refining, in view of its very high fractionating efficiency and economy of operation. It should be plainly understood, however, that the standard apparatus illustrated in Fig. 11 is very well adapted to toluol refining, the difference in

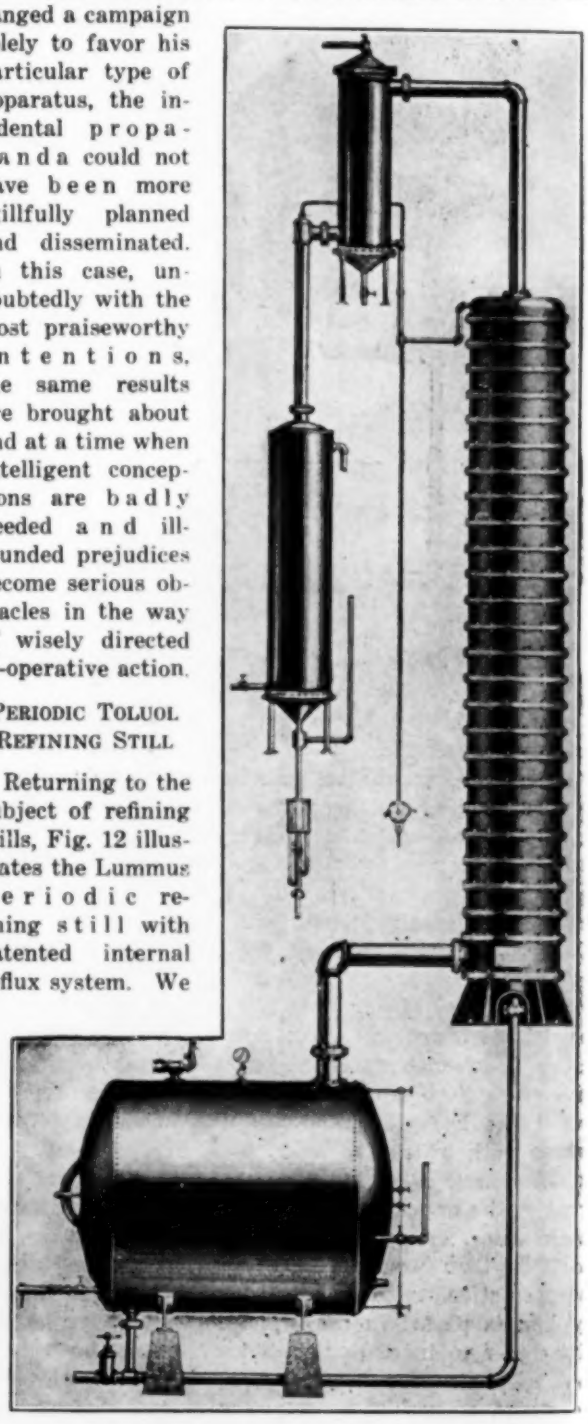


FIG. 11. BENZOL REFINING STILL WITH EXTERNAL REFLUX

favor of the more highly developed apparatus being one of degree only. That is to say, both stills are capable of turning out toluol-pure, but the Lummus type will do so with surprisingly greater economy in respect to steam and water, and the sharper separations permitted result in maximum yield of toluol-pure in one operation with correspondingly small yield of intermediate fractions requiring accumulation and subsequent re-distillation.

The Lummus refining still is constructed throughout of cast iron and steel. The still proper, or boiling kettle, is equipped with high-pressure steam coils arranged in separate groups or bundles to facilitate removal through the specially large manhole for repairs or replacement. The heating surface is arranged in most approved form, that is, a number of comparatively short tubes connected in parallel so as to maintain the velocity of the steam within the tubes and maximum average temperature difference throughout their entire length. There are no threaded joints inside the still. All joints are welded to avoid any possibility of internal steam leaks. The still is also provided with a perforated sparger pipe for injecting live steam, as in some instances preferred for distilling over the higher boiling components. The distilling column, because of its efficient design, may be considerably shorter than is necessary in the case of the standard still, and accordingly requires less building head-room. The chambers of the column are equipped with Lummus boiling caps and trapped return pipes, and the internal reflux system is in all respects similar to that described in connection with the continuous concentrator. All of the reflux tube bundles are removable without dismantling the column. The construction is very simple and durable, with all parts accessible for inspection, cleaning and repairs. The final condenser is of our vertical tubular accessible type arranged for easy cleaning of both inside and outside tube surfaces. This may be accomplished in position by removal of water jacket, vapor bonnet and liquor basin without disturbing connections and set-up of tube bundle. The outfit further includes the usual accessories, such as measuring product gage, recording thermometer, pressure and vacuum safety valves, gage glass, steam trap, etc. We have devoted considerable study during the past four years to the matter of suitable gaskets for benzol and toluol work. As a result, three types of gaskets are now successfully used for this sort of work, according to the nature of the joint to be made up.

Summarized Recommendations

Our recommendations in respect to toluol concentrating and refining are as follows:

Continuous concentration, applied to the preliminary distillation of crude toluol, insures maximum and uniform output. The continuous still once adjusted may be held at top speed production day and night except for occasional interruptions that are likely to occur in the case of all mechanical devices.

The commonly employed batch concentrating process wastes many hours of the day in dumping, charging, heating and cooling. This loss of time is entirely avoided by continuous operation.

The three products—crude benzol, crude toluol and solvent naphtha—are produced simultaneously, instead of one at a time as in the case of periodic operation. The consequent saving of time and increased output are obvious.

The Lummus double column continuous concentrator, including the internal reflux system, insures maximum economy in respect to steam and water consumption and the highest possible concentration of toluol in the crude toluol fraction. Troublesome impurities are eliminated at the start, with consequent saving of time and materials in subsequent operations.

By the interchange of heat between the crude toluol feed-liquor and the hot solvent naphtha discharged from the concentrating process, a material saving of heat is effected, all of which is entirely lost in the present periodic concentrating process. This is an especially important saving as applied to the large volume of crude light oil that must be handled to produce a comparatively small volume of crude toluol, the subsequent periodic refining of which does not involve heat losses of too great consequence.

The chemical washing apparatus, although in accordance with established practice, is of simple, durable construction, careful attention being given to mechanical features and means for preventing undue evaporation losses.

The caustic soda nuisance is eliminated through the use of dissolvers, which operate automatically, without steam or stirring, handling whole cakes rapidly and with minimum attendance.

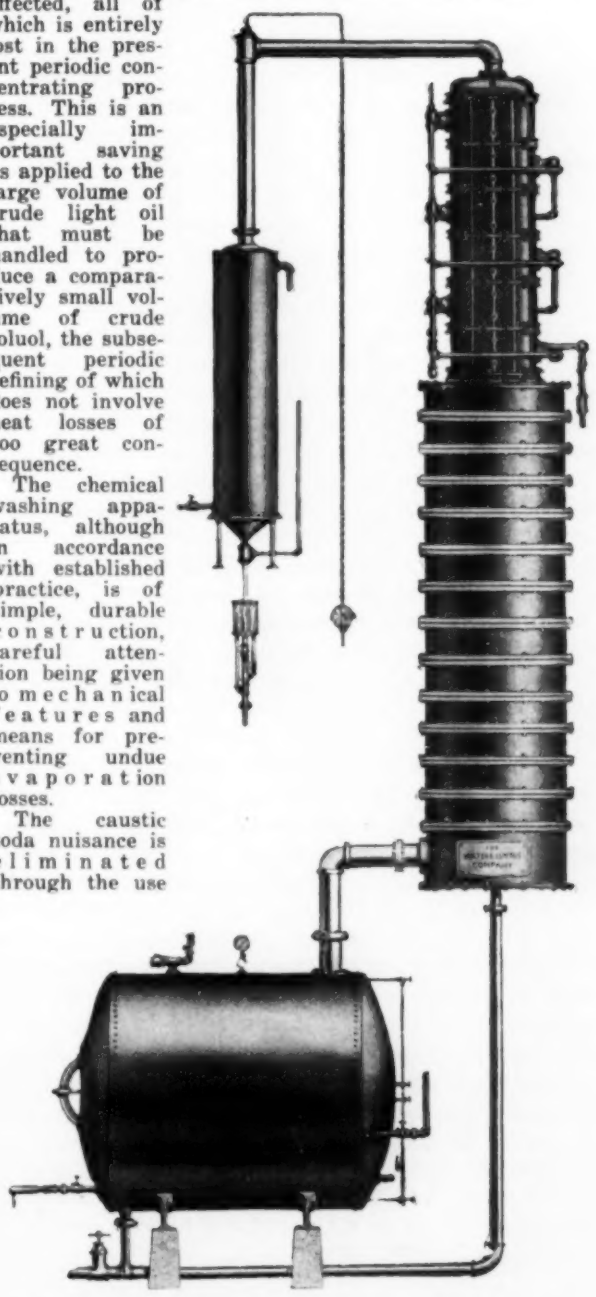


FIG. 12. TOLUOL REFINING STILL WITH PATENT INTERNAL REFLUX SYSTEM

The Lummus periodic refining still, with internal reflux system, operates with high economy of steam and water, effecting sharp separations of objectionable impurities and insuring maximum yield of toluol-pure in one operation.

Needed Improvement of the Chemical Treating Process

We are impressed with the many shortcomings of the thus far unavoidable intermediate refining operation, involving treatment of the crude toluol fraction

with chemicals for the removal of certain impurities that have appeared to be inseparable by distillation alone. Certain remarks in this connection, although perhaps more or less inconclusive, may offer something in the way of a suggestion toward future improvements in this direction. The numerous difficulties inherent in the present method of chemical treatment appear to be sufficiently obvious. At the best, it is an inconvenient and expensive step, worthy of serious effort directed toward its entire elimination or at least drastic improvement. In the first place, usable olefines and valuable phenols, if present, are entirely lost through this process. The consumption of sulphuric acid and caustic soda cannot be disregarded, and the many troublesome features introduced by the necessity of handling these materials, including the regeneration of the acid, add quite a burden to what would otherwise be a fairly clear-cut procedure. The greatest disadvantage of the chemical treatment, however, seems to rest in the unavoidable shrinkage in respect to toluol, not entirely accounted for by the mere removal of impurities other than toluol. This may be explained on the basis of sulphonation and evaporation losses, but the fact remains that valuable toluol disappears, a loss which, under present circumstances, assumes a particularly serious aspect. Furthermore, the process as now carried out, involving the periodic handling of large batches of material, certainly is not conducive to economy; and the skill and judgment demanded on the part of the operator introduces the human element and dependence thereon, which is always an obstacle in the way of efficient production.

We have been devoting considerable thought and work to this problem and feel free to state that progress thus far has been very encouraging. In view of radical departures from usual procedure, we would not consider it advisable to publish at this time the as yet incomplete results of our investigation, and must at the same time acknowledge that our experiments to date are not sufficiently final in their indications to warrant any positive prediction of success. At present we merely wish to call attention to the need of improvements in this quarter, with the hope that later we may be in position to contribute information that may prove helpful in the way of suggesting a practical solution of this problem. Should the completion of our work meet with success, we will report our findings to the proper authorities and then publish, or otherwise make available, such information as may appear generally useful.

Central Concentrating and Refining Stations

In closing this second part of our report, it is desired to comment briefly on the matter of centralized toluol concentrating and refining plants. Assuming the use of tar as the absorbing medium in the absorbing and stripping process, there appear to be no serious obstacles in the way of shipping the recovered crude light-oil fraction to large central stations for concentrating and refining, as required to produce toluol-pure. The fact that the tar makes but one passage through the system means that loss of absorbent, present in the crude light oil, may be disregarded. It stands to reason that the recovery of the light oil is a sufficient strain on the resources of the gas manufacturers, especially if smaller producers are later to be requisitioned; and it would seem undesirable to attempt the more complicated work of concentrating and refining at the various sources of toluol production, because of the large number of small refining units that would be required, which, even under the most favorable circumstances, could not turn out economically the uniform product demanded. On the other hand, a comparatively few very large refining plants, properly distributed throughout the country, could be designed and built to operate with very high economy, in that the very satisfactory results, in no other way attainable, would represent the least expense both in respect to equipment and operating cost. This plan would render possible the use of highly organized apparatus installed in very large units, which, together with scientific control and intelligent supervision, otherwise out of the question, would insure a dependable and uniform toluol production in a high degree favorable to wholesale munitions manufacture. Under any other arrangement, inadequate and inefficient types of apparatus invariably would be resorted to, and the extensive supervision necessary to maintain essential standards seems wholly impracticable. The consequent loss would, in our opinion, amount to appalling figures, due not only to the increased cost of refining, but to actual waste of toluol, measured perhaps in millions of gallons.

We therefore conclude this report with the plea that this matter of centralized refining be given most careful consideration. In fact, the arguments in its favor are so obviously convincing that we are inclined to assume that work, which we understand is already in progress, anticipates refining at large, carefully planned central refineries. These may require extra time to design and build, but in our opinion it would be better to provide extensive storage for crude light oil, produced during the interval, rather than to make the mistake of installing small refining plants for operation by the individual light-oil producer.

Part three, concluding our recommendations in respect to intensive toluol production, will deal specifically with absorbing and stripping plants graded to meet the requirements of various classes of light-oil producers, together with large central refining stations of capacity to handle the light-oil output from their respective districts. It is our hope to include brief schedules of requisite equipment for various plant capacities together with a general idea as to comparative costs.

(To be continued)

Navy Still Needs Binoculars, Spy-Glasses and Telescopes.—The Navy Department has issued a statement announcing that the Navy is still in need of binoculars, spy-glasses and telescopes. The use of the submarine has so changed naval warfare that a greatly increased lookout system is needed. All articles should be tagged, giving the name and address of the donor and forwarded by mail or express to Hon. Franklin D. Roosevelt, Assistant Secretary of the Navy, care of Naval Observatory, Washington, D. C. Articles not suitable will be returned and those accepted will be keyed and returned, as far as possible, at the close of the war. The Government will pay one dollar as rental for each article in order to comply with the law. An attempt will be made to furnish a little historical summary with those instruments which are used and are returned after the war.

Sulphur Dioxide Method for Determining Copper Minerals in Partly Oxidized Ores*

By CHARLES E. VAN BARNEVELD and EDMUND S. LEAVER

MILLING practice at the porphyry copper mines of the Southwest is in a transition stage because of the rapid changes following the introduction of flotation. Among the several problems that are receiving earnest attention from the operating companies is the recovery of the copper minerals forming the complex ores of the oxidation zone of the deposits.

This problem is under investigation at the Tucson experiment station of the Federal Bureau of Mines. A survey of the status of present laboratory practice brought out the need of a correct and rapid method for the selective determination of the quantity of copper in the sulphide form, on the one hand, and of that in the form of combined oxides, carbonates, silicates, and native or metallic copper, on the other hand, in partly oxidized ores and in mill products from these ores. Such a method is necessary for control determinations on flotation mills treating sulphide ores and also on lixiviation works using either acids or alkalines as the active solvent for the copper in oxidized and silicate form. For convenience in this report such copper is termed "oxidized copper."

Sources of Error in Methods in Use

The methods in common use for selective determination of copper minerals are the sulphuric acid method and the ammonia method. Both are unsatisfactory.

SULPHURIC ACID METHOD

The sulphuric acid method, in which a 5 per cent solution of cold sulphuric acid is used to dissolve all the oxidized copper, is unreliable for several reasons. A certain amount of metallic iron (ranging from one-tenth to one-half of one per cent) is nearly always present in the sample, introduced by the various crushing (mill) and pulverizing (laboratory) processes. This metallic iron precipitates more or less metallic copper from the copper sulphate solution formed by leaching with dilute sulphuric acid, thus giving correspondingly low oxidized copper returns. Another source of error in the same direction is the fact that dilute sulphuric acid dissolves only one-half the copper present as cuprite (Cu_2O). A serious source of error in the opposite direction, making for high oxidized returns, is the fact that chalcopyrite, bornite, and chalcocite are more or less soluble in dilute sulphuric acid (see Table I). Hence, more or less copper in sulphide form is reported as oxidized copper. It sometimes happens that the plus error due to solution of some of the copper in sulphide form is largely compensated by the minus error due to partial solution of cuprite and to deposition of copper on metallic iron. The majority of the ores tested by the writers show high oxidized and low sulphide returns, and check samples show considerable variation.

The results of tests with chalcocite and chalcopyrite, showing the solubility of the copper content in different reagents, are presented in Table I.

TABLE I—RESULTS OF LEACHING CHALCOCITE AND CHALCOPYRITE WITH 5 PER CENT SOLUTIONS OF DIFFERENT REAGENTS

The mixtures were agitated two hours on a bottle-rolling machine. Five grams of pure mineral was used for each of the mesh sizes indicated

	PROPORTION OF COPPER CONTENT LEACHED FROM—					
	CHALCOCITE WITH SOLUTION—			CHALCOPYRITE WITH SOLUTION—		
Mesh	Sulphuric Acid, per Cent	Ammonia and Ammonia Carbonate, per Cent	Sulphur Dioxide	Sulphuric Acid, per Cent	Ammonia and Ammonia Carbonate, per Cent	Sulphur Dioxide
20 to 40	0.11	3.87	None	0.03	0.12	None
40 to 65	0.28	7.50	Do.	0.04	0.18	Do.
65 to 100	0.36	14.10	Do.	0.06	0.21	Do.
100 to 150	0.60	16.60	Do.	0.15	0.32	Do.
150 to 200	0.82	17.10	Do.	0.17	0.45	Do.
200 to	2.07	22.70	Do.	0.56	0.93	Do.

AMMONIA METHOD

The ammonia method, in which a 5 per cent solution of either ammonia or of ammonia and ammonium carbonate is used to dissolve the oxidized copper, is even more unreliable than the sulphuric acid method. The results in Table I show that both chalcopyrite and chalcocite when pulverized are decidedly soluble in solutions of ammonia and ammonium carbonate, the finer the material is ground the greater is the degree of solubility. On the other hand, complete solution of the oxidized copper is rarely attained. This defect is most noticeable in ores having a siliceous gangue and in ores carrying chrysocolla. The solvent gelatinizes the silica and it appears that the formation of this gelatinous, spongy mass prevents complete decomposition of some of the copper mineral, in addition to holding dissolved copper during filtration.

Sodium Tartrate Method

While the investigation at the Tucson station was in progress, an improved method was developed by H. D. Hunt and R. V. Thurston, of the research laboratory of the Miami Copper Co. This method was brought to the writers' attention after the completion of their own work on the sulphur dioxide method described in this paper. A description of Hunt and Thurston's, which may be called the sodium-tartrate method, has been published in the September, 1917, issue of the Colorado School of Mines Magazine.[1] The procedure is essentially as follows:

PROCEDURE

Place 2 grams of pulp in a beaker, add 20 cc. of a

*Contribution from the Tucson Station, U. S. Bureau of Mines. Printed by permission of the Director.

[1] Hunt, H. D., and Thurston, R. V., The determination of oxidized copper in ores. Colorado School of Mines Mag., Vol. 7, September, 1917, pp. 157-158.

solution of caustic soda-sodium tartrate, and boil the mixture gently 5 to 10 minutes with occasional shaking of the beaker. To the hot mixture add 25 cc. of a 20 per cent solution of ammonium sulphate; heat for 10 minutes. Filter; wash several times with a hot solution of ammonium hydroxide and ammonium sulphate, and finish the washing with hot water. Neutralize the filtrate with sulphuric acid and add 2½ cc. of concentrated nitric acid. It is now ready for electrolysis.

The first treatment with solution of caustic soda and sodium tartrate effects complete and rapid solution of the azurite, malachite, and melaconite, and partial solution of the cuprite. The rest of the cuprite is dissolved later. The chrysocolla also goes into solution. Care must be taken not to boil to dryness or to a small volume. The reagent must be of sufficient strength to redissolve the copper hydroxide first formed by the action of the solution on the oxidized copper minerals in the sample. The ammonium sulphate solution has a two-fold function. It converts the excess sodium hydrate into sodium sulphate and it forms ammonium hydroxide which dissolves any remaining cuprite.

SOLUTIONS REQUIRED

The following stock solutions are required: Sodium hydrate-sodium tartrate solution, consisting of 100 grams of sodium hydrate and 50 grams of sodium tartrate dissolved in 1000 cc. of distilled water; ammonium sulphate solution, consisting of 250 grams of ammonium sulphate in 1000 cc. of distilled water; and ammonia-ammonium sulphate solution for washing, prepared by adding 100 cc. of ammonium hydroxide and 100 grams of ammonium sulphate to 1000 cc. of distilled water.

POSSIBLE SOURCES OF ERROR

In testing out this method, the writers found that it gives fairly satisfactory results on the low-grade porphyry ores for which it was developed. The method is, however, subject to two well-defined inaccuracies.

One of these arises from the fact that chalcocite is decidedly soluble in ammonia. Washing with hot solution of ammonia and ammonium sulphate unquestionably dissolves more or less copper in the form of chalcocite from the mass on the filter paper. Several tests were made of 2-gram samples containing 3 to 4 per cent of oxidized material and varying proportions of chalcocite. Mixtures containing 8, 16, and 24 per cent copper as chalcocite showed respectively 0.18, 0.33 and 0.45 per cent dissolved in washing and erroneously reported as excess oxidized copper.

Another source of inaccuracy as regards ores containing chrysocolla, results from the difficulty of washing all the dissolved copper from the gelatinized spongy mass on the filter paper. Mixtures containing 2½ to 3 per cent copper as chrysocolla showed losses ranging from 0.05 to 0.1 per cent; and mixtures containing 5 and 7½ per cent in this form, respectively, showed losses of 0.33 and 1.42 per cent. These errors tend to balance each other for ores containing both chalcocite and chrysocolla in small amounts. In analyses of ores containing less than 5 per cent copper, the resultant error (see Table II) is not serious.

SULPHUR DIOXIDE METHOD

The experiments with the sulphur dioxide method were made with the following requirements in mind:

1. The method must be applicable to a wide range of ores, and must be thoroughly reliable and rapid.
2. Copper sulphides, especially the more easily decomposed chalcocite, must not be affected by the reagent used.
3. Metallic iron must not affect the determination.

The method evolved is based on a large number of experiments, the results of which show conclusively that cuprite, melaconite, malachite, azurite, chrysocolla, and metallic copper, when finely pulverized, are readily and completely soluble in sulphur dioxide solution (sulphurous acid). Copper sulphides are not attacked, no matter how finely pulverized the mineral may be nor how long the time of contact. The two essential features of the method are: (1) fine pulverization in order to completely free the particles of copper minerals from the gangue; (2) the powdered mineral must be kept in suspension by shaking or rolling during the lixiviation or solution period.

PROCEDURE

The procedure in the sulphur dioxide method is as follows: Place 2 grams of pulp ground to a fineness of 100 to 150 mesh in a bottle, add 100 cc. of a 3 per cent solution of sulphur dioxide. Seal the bottle and agitate by rolling ½ to 2 hours. Filter; wash the residue with sulphur dioxide solution; add the washings to the filtrate, which will contain in solution all oxides, carbonates, and silicates of copper and all metallic copper. Add 5 to 10 cc. of nitric acid. Boil down to 20 cc. Dilute with distilled water to 150 cc. and determine the copper by the electrolytic method in the usual way.

The residue from filtration contains the unaltered and undissolved copper sulphide. In the experimental work the copper present as sulphide was separately determined in order to check the determination of oxidized copper. Ordinarily this step would not be necessary. In analyses of the low-grade porphyry copper ores of the Southwest, the sulphides may be readily decomposed and all the copper dissolved by proceeding as follows: To the residue add 5 cc. of sulphuric acid and 10 cc. of nitric acid and boil until dense white fumes appear. Add 5 cc. of nitric acid and dilute with distilled water to 150 cc. Determine the copper by the electrolytic method. This method of determining copper in the residue is not suited for heavy sulphide ores containing interfering bases, and for such ores standard methods should be used.

PREPARATION OF SOLUTION

Although sulphur dioxide solution (sulphurous acid) may be readily purchased, it is decidedly unstable; hence the solution should be prepared in the laboratory as needed. Small quantities are easily made by adding moderately strong sulphuric acid to scrap copper tinned on one side; the resulting sulphur dioxide gas is absorbed in water. For continuous work it is better to purchase liquid sulphur dioxide in steel cylinders and drums, which are obtainable in sizes ranging from 6-pound to 200-pound capacity. In the first experiments at the Tucson station the sulphur dioxide gas was introduced directly into the bottle containing the water and pulp. Much loss of gas resulted and the procedure was otherwise unsatisfactory.

Later the simple apparatus shown in Fig. 1 was evolved. The absorption tower *a*, 43 inches long, made

of ¾-inch to 1-inch glass tubing and filled with broken hard-burned fireclay, is set at an angle of 75 deg. between two glass bottles, *b* and *d*, of 3 to 5 gallons capacity, the bottle *b* being placed about 5 feet above the other bottle. The tower is open at the top and sealed at the bottom with a plug of sealing wax, *e*, through which two small glass tubes extend. The upper bottle, *b*, contains distilled water which is siphoned into the upper end of the absorption tower, the flow being regulated by a stop cock, *f*. A cylinder *c* (capacity 6 to 50 pounds) containing liquid sulphur dioxide is connected to one of the glass tubes extending into the absorption tower. On opening the valve of this cylinder the liquid sulphur dioxide issuing from the valve is gasified by the reduction in pressure and passes into the tower, where it is absorbed by the water from bottle *b*, converted into SO_2 solution of the desired strength and caught in the stock bottle *d*.

This apparatus gives entire satisfaction. With little attention a 3 per cent solution of sulphur dioxide may be produced at the rate of 3 liters per hour. The cylinder containing liquid sulphur dioxide, indicated in the sketch, may be replaced with a gas generator.

FIG. 1. APPARATUS FOR PREPARING SO_2 SOLUTION

STRENGTH OF SOLUTION AND TIME OF CONTACT

Considerable variation as regards strength of solution and time of contact will be necessary in treating different ores from different localities. In general, a solution containing 3 per cent SO_2 should be used. With some ores much weaker solutions, as low as 0.75 per cent SO_2, will do the work. Merely introducing the pulp into the solution, shaking the bottle for a few minutes, and letting it stand, will not dissolve the copper; constant agitation is essential. For a small number of tests a bottle-agitating machine will give satisfactory results. For analytical work where large numbers of samples are run, as in a mine laboratory, a bottle rolling machine will be found more satisfactory, not only for this purpose but for all solutions requiring constant agitation. The time of contact necessary to completely dissolve the oxidized copper minerals was found to vary from ½ to 2 hours. Most of the ores and products tested gave complete recovery in half an hour and the most refractory ores yielded in less than two hours.

To determine the strength of the sulphur dioxide solution, the following adaptation of a well known reaction is recommended; it is based on the fact that introducing either weak or concentrated sulphurous acid into a solution of iodine will result in the complete oxidation of the sulphur dioxide.

Prepare an iodine solution by dissolving 16.8 grams of potassium iodine in distilled water, adding 8.4 grams pure resublimed iodine, and shaking until the iodine is completely dissolved. The more concentrated the potassium iodide solution, the more readily will the iodine dissolve. Bring the solution to proper strength by adding enough distilled water to make a volume of 1 liter, and standardize by the thiosulphate method.

The determination is made as follows: To a measured quantity of standard iodine solution add slowly with constant stirring the proper volume of sulphur dioxide solution. So regulate the volume of iodine solution used that the mixture always contains a decided excess of iodine over the quantity required to oxidize the sulphur dioxide being added. An excess of sulphur dioxide causes the solution to clear and to lose its dark red color. If an excess of sulphur dioxide is added the determination is spoiled, and the test should be repeated with fresh sulphur dioxide solution and larger quantity of iodine solution. Thus, there is a direct ratio between the strength and quantity of sulphur dioxide solution and the quantity of standard iodine solution. In general, for solutions containing 1 to 3 per cent sulphur dioxide 1 cc., and for weaker solutions 20 cc., of standard iodine solution should be used. The mixture is then titrated by the thiosulphate method to determine the quantity of iodine remaining in the mixture. The difference between this quantity and the total quantity of iodine represents the iodine used in oxidizing the sulphur dioxide. The strength of the sulphur dioxide solution may then be calculated according to the formula:

$$SO_2 + H_2O + 2I = 2HI + SO_2$$

COMPARISON WITH OTHER METHODS

Comparative results obtained with the four methods described on ores and mill products from the Morenci,

TABLE II—RESULTS WITH THE FOUR METHODS COMPARED

Source of Sample	Copper Content Per Cent	Oxidized Copper (Oxide, Carbonate and Silicate)			
		By Sulphur Dioxide Method, Per Cent	By Sodium Tartrate Method, Per Cent	By Sulphuric Acid Method, Per Cent	By Ammonia Method, Per Cent
Inspiration mill feed	1.31	0.35	0.33	0.41	0.36
Inspiration mill slimes	0.43	.32	.28	.35	.07
Miami complex ore	2.24	1.05	1.02	1.32	.91
Morenci mill sand	.64	.09	.07	.23	.09
Morenci mill slimes	.52	.20	.18	.26	.04
Ray mill sands	.47	.04	.03	.18	.12
Ray mill slimes	.52	.27	.25	.32	.22
Chino mill heading	1.18	.19	.19	.52	.24
Chino mill tailing	.45	.13	.15	.31	.02
Chino mine ore	2.49	.95	.94	1.18	1.12
New Cornelia (Ajo) ore	1.26	.42	.42	.76	.22
Ruth mill heading	1.65	.25	.29	.41	.49
Giroux mill tailing	.58	.01	.02	.08	.04
Nevada Con. mill heading	.82	.07	.05	.30	.25
Nevada Con. mill tailing	.33	.02	.03	.08	.04
Utah copper mine ore	2.53	.24	.26	.57	.50
Utah copper mill feed	.89	.60	.56	.63	.37
Utah copper mill tailing	.63	.07	.06	.11	.09
Miami ore (special test):					
20 mesh	2.25	1.06	0.96	1.18	0.83 to 0.90
48 mesh	2.25	1.05	0.98	1.28	0.62 to 0.98
65 mesh	2.25	1.06	1.00	1.30	0.95 to 1.10
100 mesh	2.25	1.06	0.97	1.32	0.91 to 1.10
150 mesh	2.25	1.07	0.92	1.32	0.92 to 1.06
200 mesh	2.25	1.06	1.02	1.34	0.88 to 1.09

Note.—In the sulphur dioxide method any metallic copper present would be reported as oxidized copper. In the other three methods, metallic copper would be reported as sulphide.

Globe, Ray, and Ajo districts in Arizona, from Chino, from Bingham, Utah, and from Ely, Nev., are presented in Table II. The table shows that, compared with the sulphur dioxide method, the results for oxidized copper are high with the sulphuric acid method and low with the ammonia method. The sodium tartrate method shows uniformly and slightly lower returns. The last sample in the table, designated "Miami ore, special test," was crushed to 20-mesh size, special care being taken to prevent overcrushing. Five portions were then taken and crushed with the same care to the successive sizes listed. The uniform results for oxidized copper by the sulphur dioxide method is evident. The results with the sodium tartrate method, which was developed on this class of ore, show more variation and are slightly lower. The sulphuric acid method shows high returns, which are progressively higher for the finer sizes. Results with the ammonia method are low and show considerable variation.

Conclusions

Sufficient work has been done with the sulphur dioxide method to substantiate the following claims:

1. Cuprite, melaconite, malachite, azurite, chrysocolla, and metallic copper are dissolved rapidly and completely.
2. Chalcocite and chalcopyrite are not affected.
3. Metallic iron in ordinary quantities, even up to 3 per cent, dissolves rapidly and has no effect on the determination, provided there is a strong excess of SO_2.
4. There is no gelatinization of silica, and the possible loss of copper from this cause, noted in analyses by the other methods described, is eliminated.
5. The method is applicable alike to high-grade and low-grade ores. The manipulation is simple and the possible sources of error are few. One chemist can keep a 6-unit electrolytic outfit working to full capacity on porphyry ores.
6. Any metallic copper present would be reported with the oxidized copper. If a separate determination of metallic copper is considered necessary this may be made by amalgamation, preferably in an amalgamated copper pan.
7. Crushing fine enough to liberate completely the mineral particles is essential. Ores containing an appreciable proportion of chrysocolla should always be pulverized to 150 mesh.

Manganin.—Mr. M. E. Leeds of Leeds & Northrup, Philadelphia, states that manganin is difficult to obtain and is not to be had in any desirable quantities. At least one of the substitutes offered for it by an American manufacturer is, however, fully as good as manganin. It is, however, equally difficult to get, and, to the best of his knowledge, is not being produced in any sufficient quantity. There are probably several American manufacturers of alloys who could produce as good manganin as that made in Germany, and it is not so much research that is needed to help us out of the situation as it is greater productive capacity for special alloys. The manufacturers who are competent to make manganin are so overworked with orders which the Priority Board would probably consider more important that it is very difficult to get them to take the matter up.

Synopsis of Recent Metallurgical and Chemical Literature

Manganiferous Iron Ores.—U. S. Geological Survey Bulletin 666-EE by E. C. Harder gives valuable data on the deposits of manganiferous ores in the United States and their possible utilization. The dependence of the United States on imported high-grade manganese ore and ferromanganese is well known to steel makers and other users of manganese. Normally the high-grade manganese ore produced in this country constitutes less than 2 per cent of the total amount of manganese ore consumed, not including the ore represented by the manganese imported in the form of the alloys ferromanganese and spiegeleisen. During 1916 the domestic production was about three times that of 1915, largely on account of the high prices paid for ore. The exploration for new deposits has also been stimulated, and many discoveries of manganese ore are being reported. Even with this outlook for increased production, however, the author thinks it not unduly pessimistic to say that the deposits of high-grade manganese ore in the United States will probably never be able to supply the manganese consumed in domestic industries. If, therefore, the importation of high-grade manganese ore were discontinued, numerous industries would be vitally affected. Of these the steel industry consumes by far the largest quantity of manganese. The author, after giving a description of the deposits in the United States and the production of the various states, summarizes his report as follows:

There are in the United States large quantities of manganiferous ores containing varying amounts of manganese. A very small proportion of these can be used in the production of high-grade iron-manganese alloys, but a large proportion can be used for lower-grade alloys, and nearly all can be used in making high-manganese pig iron. Compared with the manganiferous ores, the reserves of high-grade manganese ores in this country are insignificant. Hence, although a search for manganese ore is desirable, a more promising solution of the manganese problem would seem to lie in the direction of the utilization of low-grade manganiferous ores. Up to the present time the use of these ores has been very slight. Until a few years ago they were considered to have little value and were mined only incidentally. In the West manganiferous ores would not be mined were it not for their association with ores of other metals.

There are several ways in which the utilization of manganiferous ores may be brought about: (1) It has been suggested that by methods of concentration resulting in the elimination of iron, silica, or other constituents a product high in manganese might be derived from them. Such concentration has been attempted locally but with very little success, owing mainly to the intimate mixture which manganese generally forms with associated materials. (2) The steel-making practice might be changed so that more spiegeleisen and less ferromanganese would be used for deoxidizing. By the addition of small quantities of high-grade manganese ore much of the manganif-

erous iron ore could be used in the manufacture of spiegeleisen. (3) The most effective solution, however, as has previously been suggested, seems to be to so change the practice in the manufacture of basic open-hearth steel as to make possible the use of high-manganese pig iron. Experimentation along this line is extremely desirable. The successful application of such a change would make large reserves of manganiferous iron ore commercially available and would greatly decrease the quantity of high-grade manganese ore consumed.

Ball Mill Tests at Inspiration.—Mr. C. T. VAN WINKLE, in a paper to be presented at the New York Meeting of the American Inst. of Mining Eng., February, 1918, on "Recent Tests of Ball-Mill Crushing," gives some hitherto unpublished data on the test conducted at the Inspiration mill at Miami, Ariz., early in 1916, when two sections were added to the mill. After outlining the experience of the Miami Copper Co. (Franke, Trans. A. I. M. E., Vol 47, page 50) and early work by Dr. Gahl at Inspiration (Trans. A. I. M. E., Vol. 55, page 576, and *Metallurgical & Chemical Engineering*, Vol. 15, page 393), the author continues:

"Early in 1916 the Inspiration company decided to add two sections to its mill, and an offer by Mr. Hardinge to equip a section with two of his mills without cost to the company was accepted. These mills were expected to do the work of the same number of Marcy mills, with much less power.

This test was begun April 4, 1917. A section comprising two 8-ft. Marcy mills equipped with 225-hp. motors, which had been in continuous operation since January, 1917, was used in comparison with a section comprising two 8-ft. Hardinge mills equipped with 150-hp. motors. Each of the Marcy mills took the original feed from the bin and, in closed circuit with a 6-ft. Dorr classifier, made a finished product.

The Hardinge mills were first arranged in tandem, the first mill taking all of the coarse feed, its product going to a Dorr classifier, the sands from which passed to the second Hardinge mill working in closed circuit with the second Dorr classifier. Each of the sections was equipped with an automatic scale so that the total or the hourly tonnage could be recorded and noted. The crushed product, the overflow from the Dorr classifiers, was carefully sampled in each case by automatic samplers. The daily report sheets of the finished product showed some variation from the desired 2 per cent on 48-mesh with both types of mills, but by applying a correction factor the final results, as tabulated, could be reduced to the basis of 2 per cent on 48-mesh. This correction factor was derived by Dr. Gahl from actual operating experience. The screen analysis of the feed was published in the *Engineering and Mining Journal*, September, 1916. The results are as tabulated below:

The daily reports show that various ball charges and various sizes of balls were used in the Hardinge mills; that the speed of the Hardinge was changed a number of times; various types of scoop feeders were used; the delays due to overloading the Hardinge mill, changing balls, etc., as mentioned, were very great. The Marcy mill continued with its ball load unchanged and practically without delays.

The record shows that the capacity of the Marcy mill was 130.5 per cent greater than the Hardinge, and the Marcy saving in power over the Hardinge was 34.04 per cent. At times the motors of both types of mills were slightly overloaded. As the power was measured by integrating wattmeters, this does not affect the results and comparisons given. The figures showing daily tonnage and kilowatt-hours per ton are averaged from the daily report sheets issued by the Inspiration management. These figures were accepted by the manufacturers of both mills, and there is no doubt as to their correctness.

Marcy Section		Hardinge Section	
Duplicate mills, 8 ft. by 72 in.		Duplicate mills, 8 ft. by 36 in.	
Spiral scoop feeders		Spiral scoop feeders on both primary and secondary mill	
Lining, Mn steel, Krupp type		Lining, Cr steel	
Grates, Cr steel, ¼-in. openings		Speed, 26 r.p.m.	
Speed, 24 r.p.m.		Motors, 150 hp.	
Motors, 225 hp.		Cr steel balls of following sizes:	
Cr. steel balls of following sizes:		Primary	Secondary
2¼ inches	1,880 lb.	5 in. 13,000 lb.	2 in. 14,500 lb.
2½–3 inches	7,290 lb.	4 in. 10,500 lb.	1½ in. 10,500 lb.
3 –3½ inches	15,445 lb.	3 in. 8,500 lb.	1 in. 7,000 lb.
	29,890 lb.	32,000 lb.	32,000 lb.
Weight of each mill (empty) and motor = 85,000 lb.		Weight of each mill (empty) and motor = 40,000 lb.	
Duplicate Dorr classifiers, 6 ft. by 26 ft. 7¾ in.		Duplicate Dorr classifiers, 6 ft. by 26 ft. 7¾ in.	
		Marcy	Hardinge
Daily tonnage (dry), corrected to 2 per cent. on 48-mesh		1118	485
Kw.-hr. per ton crushed		8.52	11.42

No ball consumption was published by the Inspiration company on the Hardinge mills because many changes had been made in the ball load. The operation of the Marcy mills was in charge of the regular mill crew, while that of the Hardinge section was under the supervision of Mr. Hardinge and his assistants, who were at the plant from April 4 to June 11, when the test was discontinued. The ball consumption of the Marcy mill in the entire plant is 1.7 lb. of steel for each ton of ore crushed.

Determination of Temperatures by Eutectic Alloys.—In the Journal of the American Chemical Society for January, 1918, Dr. C. P. STEINMETZ of the General Electric Co. gives the results of some observations on the use of eutectic alloys in temperature determinations. He says the foremost advantage expected was the far greater independence of their melting point from the purity of the material. Any impurity, such as an excess of one or more constituents, should, in cooling, crystallize out when the freezing point is approached and the alloy thus thickens before solidifying, but the final freezing point remains that of the eutectic alloy. From experiments made on various alloys with melting points below 200 deg. C., it was found, however, that material impurities caused by metals which are not a constituent of the alloy may be harmful and are to be guarded against, but a considerable deviation of the proportions of the normal constituents of the alloy appears harmless. Even the harmful effect of a foreign metal impurity probably is limited to the cases where the addition of such metal forms a eutectic alloy of lower melting point. The following twelve alloys were found by the author in the range below 200 deg. which are eutectics or sufficiently near to eutectics in their composition to permit their use, and their melting points determined by observing the freezing curves, while stirring with the thermometer. A number of observations were made with each alloy, with slightly changed composition, and by interpolation the composition of the true eutectic estimated and checked by its freezing curve.

However, neither time nor facilities were available to go very far in the investigation, and the values given in the following table thus are only approximately those of the eutectic. It would be of interest to determine the exact composition of the eutectic. This could most conveniently be done by studying the shape of the cooling curve. In the eutectic, the curve of decreasing temperature of the melted alloy follows an approximate exponential down to the constant freezing temperature. If, however, the composition is not exactly eutectic, the cooling curve deviates from the exponential when approaching the freezing point, and the temperature decreases more slowly, while the non-eutectic part freezes out.

LOW MELTING EUTECTIC ALLOYS
(Approximate)

Melting point.	Composition						Remarks	Temp. of undercooling
	Bi.	Cd.	Pb.	Sn.	Tl.	Zn.		
69.5[1]	15	3	8	4	..	..	slightly ductile	64°
90.0	7	1	6	..	..	..	ductile	83
93.5[2]	2	..	1	1	..	..	moderately ductile	91
102.4	11	4	..	5	..	..	brittle	96
132.0	11	..	9	..	..	..	ductile	127
132.5	2	..	..	1	..	..	brittle	..
143.5[3]	2	1	..	..	..	..	brittle	137
144.8[4]	..	2	5	3	..	..	ductile	137
166.5	..	..	..	4	3	..	ductile	..
172.0	..	1	..	2	..	..	ductile	..
178.3[5]	..	..	3	5	..	..	ductile	175
194.0	..	..	..	10	..	1	ductile	..

[1]Wood's metal, expands after cooling.
[2]Rose metal, expands after cooling.
[3]Combustible above melting point.
[4]Cadmium solder. Lowest melting alloy not containing the expensive bismuth.
[5]Tin solder.

It is interesting to note that the alloys which do not contain bismuth are ductile, while the alloys containing bismuth are brittle, unless they contain a large percentage of lead and little if any tin or cadmium.

Effect of Hydrochloric Acid on the Nitrogen-Hydrogen Equilibrium.—At a recent meeting of the Faraday Society in London, Dr. E. B. LUDLAM presented the results of an experimental attempt to simplify the difficult conditions of high temperature at high pressure under which the Haber synthesis of nitrogen and hydrogen to form ammonia takes place. Deville long ago proved that ammonia in the presence of hydrochloric acid gas was more stable than when alone, and it was therefore thought that the presence of hydrochloric acid during the synthesis would displace the equilibrium in the direction of the formation of ammonia by preventing the reverse change, and would remove the ammonia so quickly that the synthesis might be possible at atmospheric pressure. Some preliminary experiments gave negative results, and further showed that the problem of finding a catalyst suitable for use in the presence of hydrochloric acid was likely to prove a great difficulty. In later experiments the equilibrium was studied by attempting the reverse operation, that is, starting from ammonium chloride and decomposing it into nitrogen, hydrogen and hydrochloric acid. Various catalysts were used, but only iron gave positive results. The presence of ferrous chloride, however, introduced a new factor, and its volatility at a low temperature was a serious drawback. In any case the final equilibrium at 800 deg. C. was not displaced to any very considerable extent, and the direction of the formation of ammonia by the presence of hydrochloric acid. The result of the experiments, as far as they went, were therefore negative.

Recent Metallurgical and Chemical Patents

Catalyzers.—Four patents have been issued to CARLETON ELLIS, of Montclair, N. J., on catalyzers. The first relates to a finely divided catalyzer made by heating organic compounds such as oleates of catalytic metals, in the oil to be catalyzed. These organic compounds may be decomposed, setting free the catalyst (that is the metal) not as a pulverulent catalyzer, but as an oil colloid, the metal existing therein in a state of almost infinite subdivision, perhaps approaching molecular condition, and colloidally carried in a state of quasi solution, conducive to accelerated hydrogen absorption by the fatty or other organic materials. The second patent relates to nickel carbonyl. The third patent relates to a process of making a catalyst comprising the reduction of an organic nickel salt such as nickel acetate with a reducing gas. The fourth patent relates to a process of heating, while sealed from contact with air, a mixture of an organic compound of nickel or a metal having an atomic weight between 51 and 63.6, and a nitrate of the metal. A reduction takes place and metallic nickel or other metal used is produced. (1,251,201-2-3-4, Dec. 25, 1917.)

Metallic Alloys.—F. M. BECKET of Niagara Falls, N. Y., has patented two alloy compositions (assignor to Electro Metallurgical Co.). The first calls for an alloy essentially of

Chromium	25	- 30	per cent
Carbon	..... 1.5	- 3	per cent
Silicon	..... 0.0	- 3	per cent
Iron	73	- 63.5	per cent

forming metal of extreme toughness, hardness and freedom from oxidation and rusting. The resistance to rusting increases with the silicon, although higher silicon induces brittleness. One of the alloys resisted an oxidizing atmosphere at 1100 deg. cent. continuously for two weeks without appreciable oxidation. The alloys are markedly fibrous, can be forged, annealed, tempered and machined, and are useful as an abrasive, as non-slipping surfaces, for turbine blades, cutting tools, and high temperature work. (1,245,552, Nov. 6, 1917.)

The second alloy is of iron and cobalt approximately in the proportions of the formula Fe_3Co, with from 2 to 6 per cent of silicon, which produces a metal characterized by low hysteresis and high magnetic saturation values. These magnetic advantages increase roughly with the silicon content, and therefore the latter is kept as high as possible without destroying the malleability. Carbon is kept as low as practicable. (1,247,206; Nov. 20, 1917.)

HANS GOLDSCHMIDT and OTTO WEIL of Germany (assignors to Goldschmidt Thermit Co.) patent a method of forming high-percentage tungsten alloys. These are usually produced in electric furnaces, and therefore contain a percentage of carbon, sometimes prohibitive for certain uses. Former attempts by alumino-thermic reactions were unsuccessful, causing large slag losses of the refractory tungsten. Contrary to expectation, good yields by the latter method were obtained by adding indifferent substances to the reacting mixture,

such as lime or fluor-spar, in quantity up to one-quarter of the tungstic oxide used. (Purified scheelite, $CaWO_4$, may evidently also be used.) This process may be used for incorporating tungsten or its alloy into molten metal baths, by merely adding a mixture of ferric oxide, tungstic oxide, aluminium, and lime. The pure ferro-tungsten produced immediately alloys without waste, and the easily fusible slag remains liquid on the surface of the bath. The method is claimed to be superior to that of adding pulverized metallic tungsten or ferro-tungsten in that no carbon or oxidized impurities are added to the melt, and the waste in non-alloyed tungsten is much reduced. (1,235,969, Aug. 7, 1917.)

Production of Iron Sulphide.—A process for making iron sulphide is patented by N. G. PETINOT of New York City and assigned to the United States Alloys Corporation of New York. One method which has been used is that of heating together, at a high temperature, a mixture of three parts of iron filings and two parts of sulphur in a covered crucible. Another method is to heat together a mixture of iron sulphide and iron filings in a crucible until the whole mass was fused. Still another is that covered by U. S. Patent No. 1,169,093, issued to Mr. Petinot on Jan. 18, 1916, which consists in heating, in an electric furnace, pyrites ore containing silicious or other impurities sufficient to produce a slag, and sufficient iron to form ferrous sulphide according to the following equation:

$$FeS_2 + Fe = 2FeS.$$

The patentee states that while the last mentioned method of manufacture is better than any heretofore employed, he has found that a considerable quantity of sulphur is lost by vaporization, in spite of the protecting blanket of slag, which is formed during the working of the furnace. Moreover, the operation of the furnace is not continuous, because after the charge is fused and the chemical reaction referred to above is completed, the furnace must be tapped so as to draw off the ferrous sulphide and also the slag, and then introduce a fresh charge.

In the present process iron pyrites is used with a mixture of oxide of iron in such proportions that, when the mixture is fused, reaction occurs between its constituents. This reaction is represented by any one of the following equations:

$$3FeS_2 + 2FeO = 5FeS + SO_2$$
$$5FeS_2 + Fe_2O_3 = 8FeS + 2SO_2$$
$$7FeS_2 + 2Fe_2O_3 = 11FeS + 3SO_2$$

The mixture is, therefore, made up so as to correspond to the reactions given above; the proportions depending upon the analysis of the iron oxide used for the purpose in view. The mixture is fused in an electric furnace preferably of the Siemens type.

When the mixture is fused, the reaction occurs as indicated above, and the iron sulphide (FeS) accumulates in the bottom of the crucible, while the fused mixture of pyrites and iron oxide that still remain in their unreduced condition at the top of the furnace, form a pseudo-slag. When sufficient iron sulphide has accumulated in the crucible, it is tapped without shutting down the furnace. The furnace may also be charged without stopping the process, thus making the method of manufacture a continuous one.

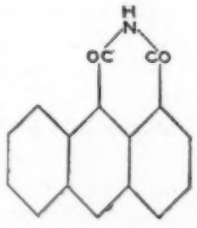
The patent states that while it is true, as indicated by the reactions shown in the equations given above, that sulphur is lost in the form of SO_2, it is to be noted that this sulphur has a useful function as a reducing agent. This sulphur removes the oxygen from the iron oxide, whereas, in the previously mentioned patent, the sulphur is lost by vaporization and, therefore, performs no useful work. (1,252,024, Jan. 1, 1918.)

Dyestuffs

Bluish-Green Vat Dyes.—MICHAEL KARDOS of Charlottenburg, and PAUL NARVIASKY of Ludwigshafen, Germany, patent a process of making certain vat dyes. The patent is assigned to the Badische Anilin & Soda Fabrik. The dyes referred to fall in a class patented under Patent No. 1,216,134, but are not specifically described in that patent. That patent claims the specific coloring matter obtainable by melting anthracene-1.9-dicarboxylic acid imid with caustic alkali, and states that this specific coloring matter yields a cherry-red vat and dyes cotton a beautiful full green. This specific dye apparently possesses an unsubstituted imid group.

The class of coloring matters described in the present patent are characterized by possessing a substituted imid group by giving from red to violet vats with alkaline hydrosulphite solutions and by yielding bluish-green shades on cotton; that is to say, they yield more bluish shades of green than does the coloring matter obtainable from anthracene-1.9-dicarboxylic acid imid.

They can be obtained by subjecting to the action of molten caustic alkali an anthracene-1.9-dicarboxylic acid imid corresponding to the formula



in which the hydrogen of the imid group has been substituted, for instance, by hydroxyl, or alkyl, or aryl. Other methods are also described. (1,253,252, Jan. 15, 1918.)

Miscellaneous Chemical Processes

Alcohol Manufacture.—BURRITT S. LACY of Sewaren, N. J., proposes to produce alcohols of the paraffin series, such as methyl alcohol, by treating alkyl halogens, such as methyl chloride, with hydroxides or carbonates of the alkaline earths. The conditions for the reaction between lime and methyl chloride are given as follows:

"(1) That the methyl chloride gas, the solution and the solid lime be vigorously and continuously agitated together.

"The probable explanation of the necessity of this is that the reaction occurs only in solution, i.e., between the dissolved CH_3Cl gas and the dissolved $Ca(OH)_2$, consequently in order to get the maximum reaction velocity the solution must be kept saturated with the CH_3Cl and $Ca(OH)_2$.

"(2) That the methyl chloride be forced into the reaction vessel at such a rate that the total pressure as registered by the gage of the reaction vessel shall be maintained at a point which is considerably above the vapor pressure of the liquid alone in the absence of methyl chloride. The difference between the total pressure as registered by the gage of the reaction vessel during reaction, and that observed when there is no methyl chloride present, I designate as the effective pressure of the methyl chloride.

"I have found that the rapidity of the reaction, other things being equal, is in direct proportion to the effective pressure of the methyl chloride.

"(3) The temperature should be considerably above 100 deg. C., as the velocity—other things being equal—increases rapidly with the temperature.

The patent is assigned to the Roessler & Hasslacher Chemical Co. of New York. (1,253,055, Jan. 8, 1918.)

Purification of Crude Benzol.—HERMAN B. KIPPER of Muskegon, Mich., proposes to purify crude benzol or light oil by treating it with a caustic soda solution which contains comminuted wood-paper pulp, or other cellulose. The hydrogen sulphide is removed and the carbon bisulphide is also almost completely removed. This is explained probably by the fact that in the manufacture of artificial silk, cellulose fiber, caustic soda and carbon bisulphide react to form the so-called "xanthates," the reaction, according to Cross and Bevan, being as follows:

$$XONa + CS_2 = C\begin{cases} SOX \\ SNa \end{cases}$$

(X representing the cellulose molecule.)

In carrying out the process, the purifying solution composed of caustic soda and the comminuted wood-paper pulp, or other cellulose, is caused to enter the top of a vessel, and the impure benzol or light oil enters the bottom of the vessel. Owing to the lighter specific gravity of the benzol or light oil as compared with the purifying solution, the benzol or light oil flows upwardly in the vessel while the purifying solution descends, and the benzol or light oil, in passing up through perforated plates, is subdivided into small drops or globules, thereby facilitating the action of the purifying solution. In consequence, the purifying solution rapidly absorbs the carbon bisulphide contained in the benzol or light oil. (1,253,048, Jan. 8, 1918.)

Purification of Potassium Chloride.—A. B. COX of Cherry Valley, N. Y., patents a process for the purification of potassium chloride which is already partly refined. The patent is assigned to the General Reduction Gas and By-Products Company of New York. Commercial potassium chloride obtained from alkali cakes may contain small amounts of sodium carbonate, borax, sodium sulphate, and also sodium chloride, which it is desirable to remove. It is proposed to add calcium chloride or a similar substance to the impure potassium chloride solution, whereby insoluble compounds are formed, except with the sodium and potassium chlorides. Fractional crystallization is then resorted to to remove the calcium chloride, the sodium and potassium chlorides remaining. One proportion of the sodium chloride is usually very small, and may be left in, or further fractional crystallization may be resorted to. (1,252,784, Jan. 8, 1918.)

United Engineering Society Officers.—The following officers were elected for the ensuing year at the annual meeting of the Trustees of the United Engineering Society, held Jan. 24, 1918: President, Charles F. Rand, Member Am. Inst. Mining Engineers; first vice-president, Calvert Townley, Member Am. Inst. E. E.; second vice-president, Robert M. Dixon, Member Am. Soc. M. E.; treasurer, Dr. Joseph Struthers, Member Am. Inst. Mining Engs.; secretary, Alfred D. Flinn, Member Am. Soc. C. E.; chairman Finance Committee, J. Vipond Davies, Member Am. Soc. C. E.

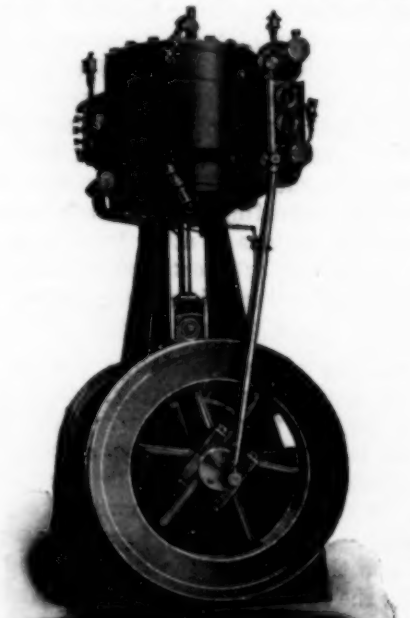
A New Vertical Rotative Dry-Vacuum Pump

A new vertical type of dry-vacuum pump is being manufactured by the Wheeler Condenser & Engineering Company of Carteret, N. J.

The pump shown was recently shipped by the manufacturers for installation in an American navy vessel.

Where much condensing is to be done and where high vacuum is to be maintained, the company recommends installing separate condensate and air pumps. Thus a motor or turbine-driven centrifugal hot-well pump can easily take care of the condensate while this Wheeler dry-vacuum air pump withdraws the air.

As the photograph shows, the inlet valves of this pump are of the semi-rotative type, which are so manipulated by the valve gear as to draw air from the condenser during its full stroke. Clearance difficulties are eliminated in this design of valve gear by providing



GENERAL VIEW OF DRY VACUUM PUMP

ports which register with an equalizing passage. The discharge valves are of the poppet type and are easily accessible, as are the other parts.

The makers state that a motor-driven dry-vacuum pump has numerous other advantages over direct steam drive, among which are: ease of installation; less attention required; no steam pipe radiation losses, and improvement of plant load factor. A few years ago it was argued that motor drive was poor practice because of the long train of elements through which power must pass before reaching the motor—the engine, generator, transmission lines, switchboard, etc.—but to-day shut-down troubles have practically vanished and authorities are strongly recommending motor-driven auxiliaries such as this dry-vacuum pump.

New Officers of American Chemical Society.—President, William H. Nichols, Jan. 1, 1918, to Dec. 31, 1918; directors: H. E. Barnard and George D. Rosengarten, Jan. 1, 1918, to Dec. 31, 1920; councilors-at-large, H. E. Howe, G. A. Hulett, W. A. Noyes, Allen Rogers, Jan. 1, 1918, to Dec. 31, 1920.

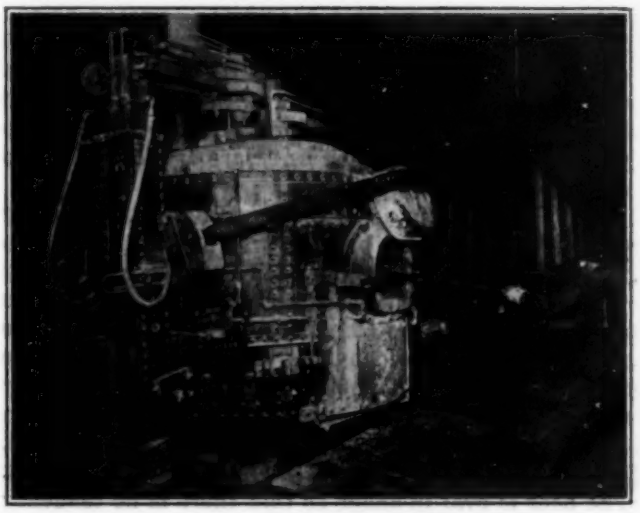
A New Electric Steel Furnace

THE Booth-Hall electric steel furnace shown in the accompanying illustrations was recently placed in operation in the plant of the Midland Electric Steel Company, Terre Haute, Ind. The furnace has a holding capacity of three to five net tons and is supplied by two single-phase transformers of 600 kva. capacity each. The transformers are Scott-connected to the 13,200-volt, 60-cycle, three-phase power line, and deliver current to the furnace at 125 volts secondary. The Scott connection gives a load well balanced over the three-phase primary circuit, as is evidenced by the meter readings. A special switch is provided for cutting the voltage in half when refining or holding heats. The electrodes are automomatically regulated and, by proper manipulation of the electrode regulators and the voltage reduction switch it is possible to put any fraction of full power into the furnace. The furnace operates at about 90 per cent power factor, giving a power input at full load of from 1000 to 1100 kw.

This furnace is built for use on either single, two or three-phase power lines and the furnace itself is built to operate either single, two or three-phase. The single-phase furnace employs an auxiliary electrode, a main electrode, a conducting hearth and a cast-steel grid buried under the hearth. The two-phase furnace employs two main electrodes and two grids, whereas the three-phase furnace employs three main electrodes but only one grid. It is anticipated that the furnace for single-phase operation will be built only in the smaller sizes, as a single-phase load of any considerable size is not acceptable to power companies. Three-phase operation will be employed only in the largest capacities where the increased number of electrodes will tend to facilitate melting down and refining. The two-phase furnace will be suitable under most conditions, and it is with such a furnace that this article deals.

Scrap steel, ranging from machine shop turnings to heavy melting steel, is charged into the furnace. When the furnace is charged the auxiliary electrode and the two main electrodes are let down until they rest upon the scrap. A pawl upon the auxiliary electrode holder is released so that the electrode rests of its own weight upon the scrap and the main electrodes are drawn up, creating an arc under each, the arc being governed by the automatic electrode regulators, assuring a uniform power imput into the furnace and a nicely balanced load in the power lines. This results in heat being generated by the two arcs from the main electrodes to the scrap, while the auxiliary electrode, under which no arc is formed, acts as the common return. By reason of the electrode resting of its own weight upon the scrap, no arc can form under the auxiliary.

When a pool has been formed on the hearth sufficient to make it conductive of electricity, the current begins to flow through the hearth and out through two sets of steel grids embedded beneath the hearth. The fact that this is taking place is immediately recorded by the ammeters, and the auxiliary electrode is then drawn out of contact with the scrap and forms its own seal of the electrode opening in the roof. The furnace then continues to operate as a two-phase



GENERAL VIEW OF BOOTH-HALL FURNACE

furnace, with two independent circuits, the current from one side of each transformer making a complete circuit through one electrode, across the arc, through the bath and the hearth to the opposing grid, and so back to the other side of the transformer.

It is to be noted that the auxiliary electrode is withdrawn before the scrap underneath melts and consequently no carbon is absorbed by the liquid steel from this source.

The advantages claimed for this principle of operation are:

(1) The use of the auxiliary electrode renders the starting of every heat positive and does away with trouble in making contact.

(2) The use of the conducting hearth gives uniform heating of the entire bath, prevents sculls and makes speedier and more thorough distribution of the heavier alloys, such as chrome, tungsten, vanadium, manganese and nickel, which sink to the bottom of the bath.

(3) The use of two independent circuits, crisscrossing in the bath, combined with bottom heating, gives a maximum circulation of the bath.

(4) The use of an auxiliary electrode in combination with a conducting hearth enables the use of a minimum number of electrodes for multi-phase service, since the auxiliary electrode is used only at the very beginning of the heat when conditions are least severe. This results in lower electrode consumption and reduction in heat losses.

(5) The hearth is solid, similar to the open hearth, with no openings or bottom contact to weaken the lining, and is sintered in place, layer by layer, forming a monolithic mass. There is no water-cooling of hearth or grids, and the operation of the furnace has shown that none is necessary.

On an absolutely cold botton it is necessary to employ the auxiliary electrode for about 45 min. before the hearth becomes conductive of electricity. On a furnace that has been shut down over night it requires from 20 to 30 min., and on a hot furnace not more than 10 min. and frequently not at all.

The Booth-Hall furnace is spherical in shape with a saucer-like bottom. The shell is made of ½-in. riveted steel plate. The main electrodes are placed on opposite sides of the furnace and the auxiliary electrode directly alongside of one of the main electrodes and toward the front of the furnace.

The furnace may be lined either basic or acid. the unit at Terre Haute being lined basic. The hearth is 24 in. thick and the grids are 18 in. below the top of

the hearth. The furnace hearth is composed chiefly of either magnesite or dolomite and is solidly sintered in, layer on layer. From the hearth up the walls are made of brick, the first three rows which reach above the slag line being made of magnesite brick and the rest of silica brick. Silica brick are employed for the roof.

The furnace door is of improved design, consisting of a door with open back to which is attached two yokes, each counter-weighted. The yokes extend part way from the door toward the sides of the furnace and by reason of the counter-weights the door can be raised with one hand by the furnace operator. The door is built in with brick, the open back allowing radiation of the heat and preserving the brick. The door pivots on the yokes as it is raised and lowered, keeping the hot inner side always to the furnace wall. The door is oval in shape so that there is no tendency to breast up the opening, as is done where round doors are employed and there is, therefore, maximum charging space. It is possible to raise the door as far as

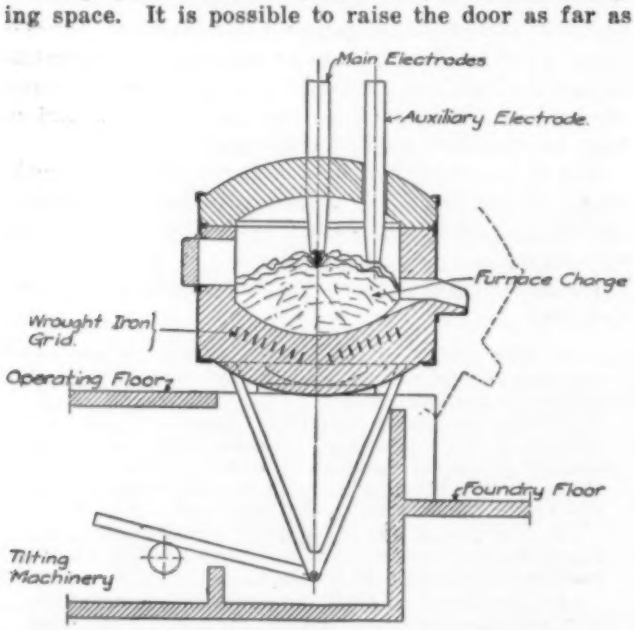


FIG. 1. DIAGRAMMATIC LAY-OUT OF TWO-PHASE FURNACE

required so that for looking into the furnace for rabbling or for taking out test ladles, the entire opening does not have to be employed. The door comes down flush against the door frame, preventing heat losses from the furnace and also the seeping of air into the furnace to disturb the furnace conditions. The door frame is made in two sections, one of which extends across the top and can be readily replaced when burnt out.

By placing the door in the rear of the furnace charging and slagging operations are simplified. By tilting the furnace forward it is possible to change the furnace quickly by the use of a hopper arrangement similar to that used for charging concrete mixers. By tilting the furnace backward it is possible to bring the slag flush with the door sill, either for rabbling or for pouring it off into slag pots. It is also practical to pour fluid slags over the charging spout.

The furnace is tilted by a very simple arrangement of rockers, structural steel struts and reducing gears. The rockers are placed under the furnace in such a way that there is no possibility of material falling on the guides and interfering with the tilt. The furnace tilts backward as well as forward, so that it is possible to bring the slag line flush with the door when slagging from the furnace, making slagging a speedier operation and easier on the furnace men.

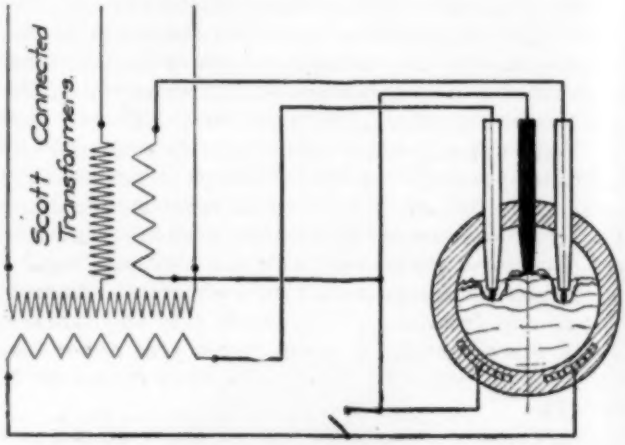


FIG. 2. ELECTRICAL CONNECTIONS FOR TWO-PHASE FURNACE

The electrode clamps are of an improved construction which allows of clamping or releasing the electrode by turning a lever at the edge of the furnace and does away with necessity of the operator climbing on the furnace roof. Each segment of the electrode clamp is water-cooled. The electrode holders are of rugged construction, each being capable of holding 10 tons at the end. Magnetic circuits are broken up by a special construction.

It will be noted in the accompanying illustrations that no electrode water cooling collars are shown in the roof, due to the fact that the temporary arrangement of three electrodes in each holder is used, and it has been found difficult to make a practical collar under the circumstances. The design of the furnace calls for a special type of electrode collar, which fits

FIG. 3. RELATIVE LOCATION OF MAIN AND AUXILIARY ELECTRODES IN SINGLE, TWO AND THREE-PHASE FURNACES

around each electrode, extending well down into the roof brick, providing further protection for both the electrodes and the roof arch at this point. Differing from other types of electric furnaces, the Booth-Hall has provided not only water-cooling collars around the electrodes, but water-cooling in the electrode clamps themselves.

The Booth-Hall electric steel furnace was originated by William K. Booth, and its mechanical design carried out by Julius R. Hall. The furnace is manufactured by the Booth-Hall Company, Chicago, Ill.

Book Reviews

COAL TAR AND AMMONIA. By *George Lunge, Ph.D.* Fifth and enlarged edition. 1658 pages. Price, $18. New York: D. Van Nostrand Company.

No book could come more opportunely at this time than this most comprehensive compilation of information regarding the most vital subjects of coal tar and ammonia.

With true European thoroughness every possible scrap of information relative to these matters has been brought together, often it seems without a sufficient amount of discrimination.

Processes and patents that have never even got beyond the paper stage are placed side by side with those that are the foundations for world industries, thus making it hard for the non-expert to discriminate with intelligence.

The first two volumes discuss at length and in considerable details not only the different methods of obtaining coal tar, but also the fractionation of the different constituents and the products obtainable from these.

The third volume discusses ammonia, and should be carefully studied by all those who to-day advocate the installation of a government nitrogen fixation plant.

The many means by which ammonia can be obtained from various waste products now going to waste in the United States is made apparent even by a cursory glancing through this volume.

The references occurring all through the three volumes are up to the very latest date.

It really goes without saying that these last volumes by Dr. Lunge are standard and are another monument erected by him to applied chemistry.

* * *

FINDING AND STOPPING WASTE IN MODERN BOILER ROOMS. By *Engineers of the Harrison Safety Boiler Works.* Cloth, 9 in. by 7 in., 276 pages, 213 illustrations. Price, $1.00. Philadelphia: Harrison Safety Boiler Works.

The saving of coal is the purpose of this handbook, which is addressed to power plant owners, managers, engineers and firemen. The preface states that such statements, tables, charts, etc., have been selected as were supported by experiments and tests, references being given wherever possible to the original authorities. The book is divided into five sections under the following headings: Fuels, Combustion, Heat Absorption, Boiler Efficiency and Boiler Testing, Boiler Plant Proportioning and Management. It is illustrated and conveniently indexed and discusses theory and practice under each heading. The compilation was made by George H. Gibson, assisted by Percy S. Lyon, now a captain in the Coast Artillery. The book contains a large amount of very useful information for anyone connected with or interested in power plant work.

* * *

TESTING FOR THE FLOTATION PROCESS. By *A. W. Fahrenwald.* Pocket size, 4 in. by 7 in., 173 pages, 34 illus. Price, $1.50. New York: John Wiley & Sons, Inc. London: Chapman & Hall.

This work is a compendium in handy form of a variety of data and information that will be useful to the metallurgist. The author has not introduced many personal ideas, but has drawn widely and freely on excellent sources of information. In this respect the book represents a condensation of the best literature, with references enabling anyone to pursue the subject further. In order to make tests intelligently it is necessary to understand fundamental principles. Hence the greater part of the book is devoted to a discussion of the physics and chemistry of flotation and the materials used in the process. The subject of colloids is clarified and condensed sufficiently to give the reader a sound idea of its relation to flotation. In like manner surface tension, capillarity, osmosis, viscosity and emulsification are discussed. Oils, addition agents and the use of sulphidizing agents receive ample consideration. When all these subjects are covered, the author devotes a chapter to tests, and discusses the effect of method of grinding, fineness of grinding, kind and amount of frothing agent used, temperature, acidity or alkalinity, varying speed of agitation and effect of addition agents. A chapter on appropriate formulas and tables completes the book.

* * *

THE LIFE OF ROBERT HARE, AN AMERICAN CHEMIST. By *Edgar Fahs Smith.* 508 pages. Price, $5.00. Philadelphia: J. B. Lippincott & Co.

The Provost of the University of Pennsylvania, better known to chemists as Prof. Edgar Fahs Smith, has made a distinct contribution to the history of modern science in this beautiful volume. Robert Hare lived in Philadelphia at a time when, as Dr. Smith says, science flourished as nowhere in America. He was born in 1781. Benjamin Franklin was still living, Joseph Priestley came later from England, James Woodhouse, fresh from the inspiration of Lavoisier, was his teacher and adviser, and these were also the days of Sir Humphrey Davy and Volta and Berzelius. With Faraday he had a long correspondence. There were giants in those days.

The Life is divided into three periods, of which the first was from his birth to 1818, or until he was thirty-seven years old. This covers the time of his study at the University of Pennsylvania, the beginning of his life-long friendship with Benjamin Silliman, and the period of his activity as a business man, during which time he never ceased to work in his private laboratory and to address himself to the study of science. His father, an Englishman by birth, who achieved prosperity by brewing porter, gave his son a sound classical education, and throughout his abundant years we find constant indications of his native and cordial familiarity with the graces of life. He succeeded his father in the administration of the affairs of Hare's brewery until near the close of the first period. In 1816 he received an honorary doctorate of medicine from Harvard College, and in 1818 he was appointed to the chair of chemistry at the school of medicine of the University of Pennsylvania. This he filled with great usefulness and distinction until his voluntary retirement in 1847, when the trustees conferred upon him the title of Professor Emeritus. He died in 1857.

He discovered the oxy-hydrogen blow-pipe. This is distinctly his invention, which he developed as a young man, shortly after leaving the University. With it he was able to melt platinum, and years afterward one of his pupils, J. Bishop, founded the platinum industry at Malvern, Pennsylvania. Another application of his discovery was the limelight, the Drummond light, so called, which gave the first powerful illumination for lighthouses. As early as 1822 he used a cathode of mercury in an aqueous electrolyte, and then and there was born the idea which led to the production of caustic soda from salt by the use of a mercury cathode in our own time. Not long afterward he brought out Hare's deflagrator, which was, in fact, a mobilized voltaic pile. Powerful deflagrators were in common use in America long before any apparatus of equal efficiency was known in Europe. Faraday declared it to be the most perfect form of the apparatus then known, and he acknowledged Hare as the inventor, although he had, at a later date, devised a voltaic trough to meet his needs that was the same in principle. Hare's calorimeter was another contribution. He originated important steps in gas analysis and he was a pioneer in the development of endometers. In 1839 he devised an actual electric furnace in which he isolated calcium, prepared calcium carbide which gave him acetylene (but which he did not recognize), and converted amorphous carbon into graphite. It was all primitive and crude, but here is the record! These are but a fraction of his contributions.

It is a book that should be in the library of every chemist who is of scholarly disposition. Correspondence, especially with Professor Silliman, fills a large part of the volume, and it is not always easy reading, because the literary habits of men of science have changed. He did not make drawings of his apparatus, he described them, and we are so accustomed to getting our ideas from drawings and so unused to descriptions without drawings to help us that the tax upon the memory while reading is unwonted and so seems severe. His language, nevertheless, was de-

lightful, and while he was a bit disputatious, it was always because of his convictions and his earnest effort to approach the truth. He was not satisfied with the distinctions between acids and bases as taught, and his views, which are presented at length, are of marked interest. He was a careful and exact thinker and a reading of this book leads to the conclusion that the progress of chemistry would have been helped by a livelier memory of the contributions of Robert Hare. We felicitate Professor Smith on his accomplishment and are thankful for the record.

* * *

SULPHURIC ACID AND ALKALI. By *George Lunge, Ph.D.* Supplement to Vol. I, Sulphuric and Nitric Acid, 4th Ed. Octavo (14 x 22 cm.), 347 pages, 25 cuts. Price, $5.00 net. New York: D. Van Nostrand Company.

Intended to supplement the 1913 edition by adding a complete record of all subsequent improvements in the art, and incidentally to save the purchasers of the 1913 books from having to buy an entirely new edition in order to get this recent literature. It looks as if the final solution might be found in resolving the treatise into a "Yahrbuch," thus bringing everyone interested up to date annually. The index includes both the subject matter of the original Volume I and of this supplement. The chapters correspond to those of the original volume, and each article is referred to the page where it fits into the earlier text. An immense amount of valuable literature is thus made available and accessible. The only criticism we have to offer is that many visionary statements and patent claims are reproduced without comment, giving to the book, in places, the character of a mere compilation rather than a treatise wherein the author is guide and mentor.

Personal

Mr. ROBERT J. ANDERSON, late chief chemist for the Cleveland Metal Products Co. is now engineer of tests of ordnance material, War Department, and is stationed at the Brier Hill Steel Co., Youngstown, Ohio.

The partnership of Falkenburg & Laucks, of Seattle, Wash., has been dissolved effective Feb 10, 1918. Mr. M. J. FALKENBURG has organized a company to be known as Falkenburg & Co., analytical and consulting chemists, Second and Yesler Sts., Seattle, Wash. Mr. I. F. LAUCKS has also established a separate business as chemist and metallurgist at 99 Marion St., Seattle.

Mr. RUSSELL T. GRAY, formerly advertising manager of the Haynes Automobile Company and more recently secretary of the Shuman Advertising Company, has opened an office in the First National Bank Building, Chicago, as an advertising engineer in the technical field.

Mr. ELLWOOD HENDRICK of New York City has allied himself with the staff of METALLURGICAL AND CHEMICAL ENGINEERING as Consulting Editor. For some time past Mr. Hendrick has been an occasional editorial contributor to this journal, and his intimate familiarity with phases of our rapidly growing chemical industry will assist us materially in reflecting conditions in that important branch of the field to which our pages are devoted.

Mr. A. G. MCGREGOR, who erected the International, Calumet & Arizona, Verde Extension and other reduction works in the Southwest, has returned to Arizona from New York and is expected to sail at an early date for Chile and Peru with representatives of copper interests.

Mr. WILLIAM PIGGOTT of Seattle, Wash., president of the Seattle Car & Foundry Co., and vice-president of the Pacific Coast Steel Co., has been placed in charge of wooden shipbuilding for the United States Shipping Board in the Seattle district. Mr. Piggott will succeed Capt. J. F. Blaine, who will retain charge of the steel ship construction.

Dr. CHARLES L. REESE, Chemical Director of the E. I. du Pont de Nemours Co., has been elected chairman of the Philadelphia Section of the American Chemical Society. Dr. Reese was recently elected a director of the du Pont Company.

Mr. S. S. SADTLER of Philadelphia was in New York on business during the first week of February.

Mr. WILLIAM WRAITH, general manager of the International Smelting Company has gone from Salt Lake City to New York to assume additional duties as vice-president of the Andes Copper Mining Co. Mr. Wraith expects shortly to make a trip to South America in connection with plans for development of their low-grade copper deposits at Porterillas, Chile. O. M. KUCHS, since 1913 superintendent of the Tooele smelter of the International Smelting Co., has assumed the position of assistant general manager with headquarters in Salt Lake City, while A. B. YOUNG, superintendent of the blast furnace department has been made superintendent of the smelting plant.

Current Market Reports

The Iron and Steel Market

The iron and steel industry has felt practically no results from Fuel Adiminstrator Garfield's fuel conservation order. There has been practically no ultimate loss of production, as the blast furnaces were permitted to operate and any pig iron accumulated can either be used in steel production or be set aside as a convenient reserve. Transportation conditions have not been improved, but it is conceded in most quarters that had it not been for the fuel order they would have become still worse.

PRODUCTION LIGHTER

Blast furnace operations have been still lighter, the past two or three weeks seeing the smallest production of pig iron in this whole period of restricted operations. Apart from the general railroad blockade there have been particularly bad weather conditions in the Connellsville coke region, and not only have coke receipts at furnaces been very light, but pig iron production in proportion to coke has been particularly light. Many furnaces, through frequent bankings, have been showing a coke consumption of 2800 to 3000 lb. per ton of pig iron. Many furnace managers are making a careful effort to anticipate coke supplies and operate their furnaces with correspondingly light blasts, so as to insure regular and continuous operation, no matter how light the output. One furnace manager claims to have operated for a considerable period with an output 50 per cent of normal, yet with a coke consumption of only 2400 lb.

The blast furnaces of the Central West depending upon Connellsville coke have been producing an average of 25 to 40 per cent of their capacity in pig iron. Blast furnaces depending upon by-product coke have done much better, possibly 75 per cent. The difference is not in transportation conditions in general, but that the Government favors the movement of by-product coal, not on account of the coke it produces, but on account of the by-products. In other words the real condition is that the coke is the by-product and the toluol, etc., the product. One recalls the time when the first Gary blast furnaces were put in operation, not so much for the purpose of supplying pig iron as for the purpose of supplying gas for the first run of the steel department. The pig iron could be secured elsewhere, the gas could not.

While the supply of pig iron is thus very much restricted, the ability of mills to ship finished steel is at least equally restricted, and it is a question whether steel mill operations as a while are being limited the more by shortage of raw material or inability to dispose of finished product. There is practically no storage capacity left in mill warehouses or yards, and production in nearly all finishing departments is regulated by car supplies and permits to ship. Unfortunately these two necessary elements are not always synchronous. One may load steel and wait for a permit, paying demurrage meanwhile, or seek a permit first and then see its time limit pass while one is waiting for cars.

Shipments of finished steel products from mills in the past fortnight have averaged somewhat less than 60 per cent of capacity. This means more than 60 per cent of the output in 1916, as while the mills operated full in that year, the capacity at present is much larger, by between 10 and 15 per cent. Fully two-thirds of the shipments have been of war steel, leaving commercial shipments at not more

than 20 per cent of capacity. Not all war steel on order is possible of shipment, however, there being various restrictions in that quarter also.

Despite the fact that steel receipts by ordinary commercial consumers are only about 20 per cent of the productive capacity, there is no particular complaint, as to shipments, on the part of buyers. There operations are equally restricted by the transportation situation.

THE OUTLOOK

The iron and steel industry has nothing but an outlook. There has been no market for weeks past, and there will be no regular market until the transportation situation has been loosened up and the business of making and consuming steel, at something like a normal rate, can be resumed. Presumably the backbone of winter has been broken, and the common view in the trade is that the effectiveness of the railroads is going to be greatly increased by the advent of respectable weather, the chief menace now being that of floods. The congestion may clear rapidly, but in all probability the clearing will be sporadic geographically, and that may introduce fresh complications. That the steel industry will follow closely upon the heels of the railroads is certain. As transportation conditions improve steel production will at once increase.

There is very little attempt to speculate what will be done or will not be done at Washington against the date, March 31, to which the set prices were continued by the President's announcement late in December. A great deal can occur, as to consumption and production, before that time. The question of costs, so much discussed in the late months of last year, is a dead issue. There are no costs, according to the common view of costs. There is simply a total of expenses, made up in altogether unusual manner, and a total of tons that chanced to be shipped. Dividing the one by the other means nothing as to next week or next month.

The Navy Department's experiment of inviting competitive bidding on the purchase of a variety of steel products is an interesting departure. Hitherto the placing of orders has been in the form of allotments, the set prices being taken as a matter of course. The competition has resulted in some prices being made, chiefly for manufactured steel such as rivets, nuts and bolts, etc., at materially lower than the set prices. Doubtless Washington will be disposed to carry the experiments farther. As a buyer the Government has an advantage at the moment it does not ordinarily enjoy. Government red tape is as objectionable as formerly, but there is the great distinction that if one has a Government order his chances of being able to ship the material are very much greater than if the order is for ordinary commercial steel.

Thus the main outlook the iron and steel market has at this writing is that within the next few weeks there are likely to be physical and other developments of fundamental importance, that will furnish a basis on which the future of tonnage and prices can be considered.

Non-Ferrous Metal Market

Friday, Feb. 8.—Conditions are unchanged in the copper market with inactivity prevailing. Tin is just as scarce and is higher. Lead is dull but remains firm. Spelter is still dull and somewhat unsettled.

Tin—Supplies of spot tin of any size are hard to locate and no Straits tin is offered for sale. Arrivals in January were less than 2000 tons, and so far this month 175 tons have arrived with 5350 tons reported afloat from the Straits. *The American Metal Market* says: "The combination of a further advance abroad, heavy inquiry here, and the non-receipt of private offers have caused an extremely strong market and there is greater irregularity than ever between different sellers' prices, some having practically withdrawn from the market in anticipation of further advances.

"Some values in various positions are approximately as follows:

"Ninety-nine per cent quality for delivery in a week or so at 78c. per pound.

"Banca tin on steamer actually afloat at 73.50c.

"Banca tin February shipment from Batavia at 70c.

"Banca tin March shipment from Batavia at 69.50c."

Copper—Better weather conditions are expected to relieve the transportation situation and to afford relief in the way of supplies of matte and blister copper for the Eastern refineries. The market is comparatively dull and unchanged at the Government price of 23.50c. for producers and 24.67½c. for jobbers.

Lead—The trust price in New York remains at 6.75 with outsiders asking 7c. as a minimum. The St. Louis market is around 6.80c. Supplies are not large, owing to the railroad congestion, but better weather is expected to afford relief.

Spelter—The market continues quiet. No price has yet been fixed for Grade A, although numerous rumors were around that 12c. had been agreed upon. Prime Western is held at 8c., New York and 7.75c. at St. Louis.

Tungsten—Scheelite is offered at $30 by California producers but no sales are reported at that figure. Importers report the nominal price of $26 for scheelite and $20 to $26 for wolframite. Tungsten, molybdenum, vanadium, manganese, chrome and ferro-alloys come under the license authority of the American Iron and Steel Institute in so far as these ores are imported from abroad. Importer dealers and consumers are henceforth required to give a guarantee before shipments are released to them.

Molybdenum—Charles Hardy reports considerable activity in molybdenite at $2.15, basis 85 per cent. Arrivals in the East have lately increased but have been readily absorbed.

Quicksilver—California virgin is quoted at $130 with Mexican at $120.

Chrome—Ore is still scarce and higher.

OTHER METALS

Aluminium, lb.	.36–.38
Bismuth, lb.	2.50–2.75
Cadmium, lb.	1.50
Nickel, electrolytic, lb.	.55
Silver, oz.	.86⅛
Platinum, oz.	105.00
Palladium, oz.	130.00–135.00
Cobalt, lb.	3.25–3.50
Magnesium, lb.	2.00

Chemical Market

COAL-TAR PRODUCTS: Quiet prevailed in this situation during the interval. Transit conditions, as well as the inability of plants to secure sufficient coal to operate up to regular schedule, tends to restrict operations. With the government taking over several of the important items the trade is evidently delayed in acclimating itself to the new conditions created.

Benzol: While there are more contracts being closed over the next few months than for some time heretofore, there are not many contracts being closed over the entire year. Spot supplies are plentiful and prices are low.

Phenol: There is but little material offered at this time. The government has contracted for practically all the material to be produced for some time to come.

Toluol: Several dealers have succeeded in securing material which has been selling at fancy prices, but the government is following up the matter and has seized several lots in the past few days.

Naphthalene is not active. Both buyers and sellers appear to be giving the matter but little attention. Prices are unchanged.

Aniline Oil has been advanced in price because of the scarcity and high prices of the necessary acids.

Aniline Salt is fairly firm with low offerings absorbed and producers quoting an advance of a cent or two.

Dimethylaniline: The demand is quiet, but offerings are light and prices are fairly well maintained.

Diethylaniline: There are but few producers of this material and offerings are so light that quotations are nominal.

Diphenylamine: This material is in heavy demand by explosive manufacturers, and there is practically none available in the open market.

Benzoate of Soda is held in speculative hands, with producers sold up and prices fluctuating over a wide range.

Saccharine: Surplus quantities are flooding the market because of the falling off in the export demand, and prices have been reduced by more than 50 per cent.

Salicylic Acid: With a heavy output and only a routine demand a break in price has resulted.

Para Nitro Phenol: The production is restricted to a few quarters ; the demand is fair and prices are well maintained.

HEAVY CHEMICALS.—As a result of the freight embargoes and the order of the fuel administration there has been a gradual readjustment of chemical values. Buyers, owing to the uncertainty of deliveries, have not shown any particular desire to purchase for shipment from works. There has however been a gradual improvement in the demand for spot lots and for material at near-by shipping points, and these offers have generally commanded a premium. As a result of greatly restricted shipment during January bills of lading of that month are in particular demand in order to carry out contracts to the letter.

Caustic Soda: From a product highly speculative the movement in caustic has been of such minor consequence that many items other than this have shown more activity. During the early weeks of January there was practically no activity noted. As the movement closed it was apparent that January shipments from works were very meager, and those who had sold actual January shipment now find a market of approximately 6.40 for these bills as against 5.45 for February shipment. For shipment, March sales have occurred at 5.35, but this price is low. Producers are not inclined to go much below 5.50 for any position up to June.

Soda Ash: There has been a very urgent request for prompt ash in barrels, and it is apparent export permits have been granted for important amounts. Barrels have sold as high as 3.45, and at the moment there is practically no material available in New York in this package. Bags have not been in such urgent request, and the market remains at about 3c. for spot and from works. Dense ash continues scarce and single bags are held at 3.85 barrels and double bags at 4c.

Sulphuric Acid: Considerable acid has appeared on the market during the interval, not due to any increased output but to the fact that acid has backed up on producers, who have found it difficult to ship in face of the embargoes. Tank cars are so scarce that much acid that would be otherwise bought remains at producing point owing to lack of carrying room. Sixty-six-degree acid has been available at prices ranging from $38 to $42, seller's tanks, works. For export there has been considerable business passing in drums at $90 f.a.s., drums included. Sixty-degree acid has been offered at $32.50 works, seller's tanks.

Muriatic Acid: The product continues scarce. Practically no test other than 20 is offered. Weak acid does not attract a buyer, and in view of the high prices obtained for the 20-deg. manufacturers see no profit in concentrating to 22 deg. Contracts have been offered of 20 deg. at 2.50 to 2.65 works, car quantities.

Nitric Acid: Off-colored material has been available at 9c., but pure white acid 42 deg. is held at 9½ to 10c. works.

Cyanide of Soda: There has been more activity noted and prompt material has sold at 43½c., although at the moment of writing there are lots available at 42c.

Copper Sulphate: Both Nichols and A. S. & R. brands have been offered by second hands at prices ranging from 8.70 to 9c. Sales have occurred in fairly large quantities at 8⅞c., and the second-hand market has been fairly well cleaned up. Nine cents is now a good price from second hands. Producers are quoting 9½c. All prices are for 99 per cent large crystals, prompt shipment.

Bichromates: The spot market has again developed into a speculative one, and there is again evidence of manipulation. Spot lots have generally commanded considerable attention and sales have occurred at from 20c. to 24c. From works sellers quote 22c. to 24c. and even higher for late deliveries. The potash material has been neglected and there have been actual offers at 41c.

Chlorate of Potash: The American producers have seemingly gone after the Japanese producers with a big stock. Although for domestic consumption 40c. to 42½c. are the lowest prices obtainable for export, 35c. and 36c. have been named with the broad intimation that even lower prices would be considered if necessary. For domestic business a resale occurred at 36c., but aside from this there does not appear to have been much business undr 40c. Japanese material has sold at 35c. and 36c. rolling to New York

Sodium Sulphite: Prompt stocks have been about eliminated from the market. For March shipment there are sellers of the 99/50 per cent moisture at 5c., New York.

Sodium Sulphide: Spot values have advanced to 5c for the 60/62 per cent fused. From works sellers quote 4¾c. to 4⅞c.

Hydrosulphite of Soda: There are offers of the powdered at $1.45 and a 10 per cent liquid is offered at 6½c.

Hyposulphite of Soda: Spot lots have changed hands at 2½c., and contracts are available at 2c. works for tanners' size. Pea size is held at approximately ½c. higher.

Prussiates: The sodium salt has been very scarce, and spot values have advanced to 37½. The yellow potassium salt has been somewhat easier and there are supplies available at $1.22½.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, FEB. 7, 1918

Acetic anhydride	lb.	1.35 —	1.50
Acetone, drums	lb.	Nominal	
Acid, acetic, 28 per cent	lb.	.05½ —	.06
Acetic, 56 per cent	lb.	.11½ —	.12
Acetic, glacial, 99½ per cent, carboys	lb.	.34 —	.35
Boric, crystals	lb.	.13½ —	.14¼
Citric, crystals	lb.	.75 —	.78
Hydrochloric, C. P	lb.	Nominal	
Hydrochloric, 20 deg	lb	.02½ —	.03
Hydrochloric, conc., 22 deg	lb.	.03 —	.03½
Hydrofluoric, 30 per cent, in barrels	lb.	.06 —	.06¼
Lactic, 44 per cent	lb.	.15 —	.15½
Lactic, 22 per cent	lb.	.05½ —	.06½
Nitric, 36 deg	lb.	Nominal	
Nitric, 42 deg	lb.	.09½ —	.09½
Oxalic, crystals	lb.	.45½ —	.46½
Phosphoric, 47-50 per cent crude	lb.	.07½ —	.08
Phosphoric, ref. 50 per cent	lb.	.26 —	.....
Picric	lb.	Nominal	
Pyrogallic, resublimed	lb.	3.15 —	3.25
Sulphuric, 60 deg	ton	..... —	35.00
Sulphuric, 66 deg	ton	40.00 —	45.00
Sulphuric, oleum (Fuming), tank cars	ton	75.00 —	80.00
Tannic, U. S. P., bulk	lb.	1.30 —	1.35
Tartaric, crystals	lb.	.75 —	.78
Tungstic, per lb. of W	lb.	1.80 —	1.90
Alcohol, sugar cane, 188 proof	gal.	4.85 —	.....
Alcohol, wood, 95 per cent	gal.	1.35 —	1.38
Alcohol, denatured, 180 proof	gal.	.69 —	.70
Alum, ammonia lump	lb.	.04½ —	.05
Alum, chrome ammonium	lb.	.18½ —	.19
Alum, chrome potassium	lb.	.21 —	.23
Alum, chrome sodium	lb.	.12½ —	.13
Alum, potash lump	lb.	.09 —	.09½
Aluminium sulphate, technical	lb.	.02 —	.02½
Aluminium sulphate, iron free	lb.	.03½ —	.04
Ammonia aqua, 26 deg. carboys	lb.	.19½ —	.20
Ammonia, anhydrous	lb.	.40 —	.43
Ammonium carbonate	lb.	.10¾ —	.11
Ammonium nitrate	lb.	(Fixed price)	.14
Ammonium, sulphate domestic	lb.	.07¼ —	.07½
Amyl acetate	gal.	5.00 —	5.25
Arsenic, white	lb.	.16¼ —	.16½
Arsenic, red	lb.	.65 —	.70
Barium carbonate, 99 per cent	ton	80.00 —	90.00
Barium carbonate, 97-98 per cent	ton	65.00 —	67.00
Barium chloride	ton	70.00 —	90.00
Barium sulphate (Blanc Fixe, powder)	lb.	.03¾ —	.04
Barium nitrate	lb.	.12 —	.14
Barium peroxide, basis 70 per cent	lb.	.30 —	.32
Bleaching powder, 35 per cent chlorine	lb.	.02½ —	.02¾
Borax, crystals, sacks	lb.	.07¼ —	.08¼
Brimstone, crude	ton	Nominal	
Bromine, technical	lb.	.75 —	.....
Calcium, acetate, crude	lb.	Nominal	
Calcium, carbide	lb.	.13½ —	.14½
Calcium chloride, 70-75 per cent, fused, lump	ton	21.00 —	22.00
Calcium peroxide	lb.	1.60 —	1.70
Calcium phosphate	lb.	.34 —	.35
Calcium sulphate	lb.	..... —	.....
Carbon bisulphide	lb.	.07½ —	.08
Carbon tetrachloride, drums	lb.	.16 —	.17
Carbonyl chloride (phosgene)		..... —	.....
Caustic potash, 88-92 per cent	lb.	.84½ —	.85
Caustic soda, 76 per cent	lb.	.05¾ —	.06½
Chlorine, liquid	lb.	.15 —	.18
Cobalt oxide	lb.	1.40 —	1.50
Copperas	lb.	.01¼ —	.01½
Copper carbonate	lb.	.45 —	.....
Copper cyanide	lb.	.75 —	.78
Copper sulphate, 99 per cent, large crystals	lb.	.09 —	.09½
Cream of tartar, crystals	lb.	.61 —	.63
Epsom salt, bags	lb.	.03 —	.03¼
Formaldehyde, 40 per cent	lb.	.20 —	.21
Glauber's salt	100 lb.	1.00 —	1.10
Glycerine, bulk, C. P	lb.	.67½ —	.70
Iodine, resublimed	lb.	4.25 —	4.35
Iron oxide	lb.	.13 —	.15
Lead, acetate, white crystals	lb.	.17 —	.17½
Lead arsenate (Paste)	lb.	.15 —	.18
Lead nitrate	lb.	.15 —	.16
Litharge, American	lb.	.09½ —	.11½
Lithium carbonate	lb.	1.50 —	2.00
Manganese dioxide, U. S. P.	lb.	.70 —	.75
Magnesium carbonate, technical	lb.	.09½ —	.10
Nickel salt, single	lb.	.14 —	.15
Nickel salt, double	lb.	.12 —	.14
Phosgene, see Carbonyl chloride		..... —	.....
Phosphorus, red	lb.	1.35 —	1.40
Phosphorus, yellow	lb.	1.25 —	.....
Potassium bichromate	lb.	.43 —	.45
Potassium bromide granular	lb.	1.35 —	1.50
Potassium carbonate calcined, 85-90 per cent	lb.	.50 —	.55

Potassium chlorate, crystals	lb.	.40 —	.42½
Potassium cyanide, 98-99 per cent	lb.	Nominal	
Potassium iodide	lb.	3.75 —	3.80
Potassium muriate 80-85 p. c. basis of 80 p. c	ton	350.00 —	.....
Potassium nitrate	lb.	.30 —	.32
Potassium permanganate (U. S. P.)	lb.	4.00 —	4.10
Potassium prussiate, red	lb.	2.60 —	2.70
Potassium prussiate, yellow	lb.	1.25 —	1.27
Potassium sulphate, 90-95 p.c. basis 90 p.c	ton	Nominal	
Rochelle salts	lb.	.39 —	.39½
Salammoniac, gray gran	lb.	.17 —	.17½
Salammoniac, white gran	lb.	.15 —	.16
Sal soda	100 lb.	1.25 —	1.30
Salt cake	ton	22.00 —	23.00
Silver cyanide, based on market price of silver	oz.	..... —	.....
Silver nitrate	oz.	.57 —	.58
Soda ash, 58 per cent, light, flat	100 lb.	3.00 —	3.05
Soda ash, 58 per cent, dense, flat	100 lb.	3.80 —	4.00
Sodium acetate	lb.	.16½—	.17
Sodium bicarbonate, domestic	lb.	.02½—	.03
Sodium bicarbonate, English	lb.	..... —	.....
Sodium bichromate	lb.	.22 —	.24
Sodium bisulphite, powd	lb.	.06¼—	.06½
Sodium chlorate	lb.	.24 —	.25
Sodium cyanide	lb.	.42 —	.44
Sodium fluoride, commercial	lb.	.18½—	.....
Sodium hyposulphite	lb.	.02½—	.....
Sodium molybdate, per lb. of Mo	lb.	2.50 —	
Sodium nitrate, 95%	100 lb.	4.35 —	4.50
Sodium nitrite	lb.	.30 —	.35
Sodium peroxide	lb.	.45 —	.50
Sodium phosphate	lb.	.04 —	.04½
Sodium prussiate, yellow	lb.	.37½—	.40
Sodium silicate, liquid (60 deg.)	lb.	.03½—	.04½
Sodium sulphide, 30 per cent., crystals	lb.	.02¾—	.03
Sodium sulphide, 60 per cent., fused	lb.	.05 —	.05½
Sodium sulphite	lb.	.05 —	.06
Strontium nitrate	lb.	.25 —	.35
Sulphur chloride, drums	lb.	.06 —	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15 —	.40
Sulphur, flowers, sublimed	100 lb.	4.05 —	4.10
Sulphur, roll	100 lb.	3.70 —	3.85
Sulphur, crude	ton	Nominal	
Tin bichloride, 50 deg	lb.	Nominal	
Tin oxide	lb.	.75 —	.90
Zinc carbonate	lb.	.25 —	.30
Zinc chloride	lb.	.10¼—	.11
Zinc cyanide	lb.	Nominal	
Zinc dust, 350 mesh	lb.	.17 —	.18
Zinc oxide, American process XX	lb.	.12½—	.13
Zinc sulphate	lb.	.06 —	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.35 —	.40
Benzol, 90 per cent	gal.	..... —	.....
Toluol, pure water white	gal.	Nominal	
Xylol, pure, water white	gal.	.35 —	.50
Solvent naphtha, water white	gal.	.17 —	.22
Solvent naphtha, crude, heavy	gal.	.13 —	.16
Creosote oil, 25 per cent	gal.	.33 —	.35
Dip oil, 20 per cent	gal.	.29 —	.30
Pitch, various grades	ton	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05 —	1.10
Carbolic acid, crude, 50 per cent	lb.	.60 —	.65
Carbolic acid, crude, 25 per cent	lb.	.35 —	.38
Cresol, U. S. P	lb.	.18 —	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00 —	1.25
Alpha naphthol, distilled	lb.	1.60 —	2.00
Alpha naphthylamine	lb.	.58 —	.60
Aniline oil, drums extra	lb.	.27 —	.28
Aniline salts	lb.	.32 —	.34
Anthracene, 80 per cent	lb.	.50 —	.65
Benzaldehyde (f.f.c.)	lb.	4.50 —	5.50
Benzidine, base	lb.	1.75 —	1.85
Benzidine, sulphate	lb.	1.40 —	1.50
Benzoic acid U. S. P	lb.	5.50 —	5.75
Benzoate of Soda, U. S. P	lb.	5.00 —	5.25
Benzyl chloride	lb.	2.25 —	2.50
Beta naphthol benzoate	lb.	10.00 —	12.00
Beta naphthol, sublimed	lb.	.85 —	.90
Beta naphthylamine, sublimed	lb.	2.65 —	
Dichlor benzol	lb.	.12 —	.18
Diethylaniline	lb.	4.00 —	5.00
Dinitro benzol	lb.	.35 —	.40
Dinitrochlorbenzol	lb.	.40 —	.42
Dinitronaphthaline	lb.	.55 —	.60
Dinitrotoluol	lb.	.55 —	.60
Dinitrophenol	lb.	.50 —	.55
Dimethylaniline	lb.	.57 —	.62
Diphenylamine	lb.	.85 —	1.00
H-acid	lb.	2.25 —	2.50
Metaphenylenediamine	lb.	1.85 —	2.00
Monochlorbenzol	lb.	.19 —	.22
Naphthalene, flake	lb.	.09½—	.09¾
Naphthalene, balls	lb.	.10½—	.10¾
Naphthionic acid, crude	lb.	1.40 —	1.50
Naphthylamin-di-sulphonic acid	lb.	1.00 —	1.10
Nitro naphthaline	lb.	.45 —	.50
Nitro toluol	lb.	.50 —	.55
Ortho-amidophenol	lb.	..... —	.....
Ortho-dichlor-benzol	lb.	.15 —	.18
Ortho-toluidine	lb.	1.00 —	1.20
Ortho-nitro-toluol	lb.	.75 —	1.00
Para-amidophenol, base	lb.	3.50 —	4.00
Para-amido-phenol, H. Ch	lb.	4.00 —	5.00
Para-dichlor-benzol	lb.	.12 —	.15
Paranitraniline	lb.	1.05 —	1.15
Para-nitro-toluol	lb.	1.50 —	1.60
Paraphenylenediamine	lb.	3.00 —	3.50
Para toluidine	lb.	2.25 —	2.50
Phthalic acid anhydride	lb.	4.50 —	5.00
Phenol, U. S. P	lb.	.53½—	.55
Resorcin, technical	lb.	6.00 —	7.00
Resorcin, pure	lb.	10.00 —	12.00
Salicylic acid	lb.	1.00 —	1.10
Salol	lb.	1.85 —	2.00
Sulphanilic acid, crude	lb.	.32 —	.35
Tolidin	lb.	2.50 —	.....
Toluidine-mixture	lb.	.75 —	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	3.75 —	.....
Corning, Ohio	bbl.	2.80 —	.....
Somerset, Ky	bbl.	2.55 —	.....
Wooster, Ohio	bbl.	2.38 —	.....
Indiana	bbl.	1.98 —	.....
Illinois	bbl.	2.12 —	.....
Oklahoma and Kansas	bbl.	2.00 —	.....
Caddo, La., light	bbl.	2.00 —	.....
Corsicana, Tex., light	bbl.	2.00 —	.....
California	bbl.	.98 —	1.32
Gulf Coast	bbl.	1.00 —	.....

Fuel Oil

New York	gal.	.11 —	.....
Pittsburgh	gal.	.07½—	.10
Oklahoma-Kans	bbl.	1.50 —	2.35
Texas	bbl.	1.50 —	1.75
Los Angeles	bbl.	1.52 —	.....
San Francisco	bbl.	1.45 —	.....

Gasoline (Wholesale)

New York	gal.	.24 —	.....
Boston	gal.	.25 —	.....
Pittsburgh	gal.	.26 —	.....
Chicago	gal.	.21 —	.....
Oklahoma	gal.	.25 —	.....
San Francisco	gal.	.20½—	.....

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.19 —	.20
Cylinder, light	gal.	.34 —	.35
Cylinder, dark	gal.	.33 —	.34
Paraffine, high viscosity	gal.	.36 —	.37
Paraffine, 903 sp. gr	gal.	.29 —	.30
Paraffine, .865 sp. gr	gal.	.21 —	.22

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida	gal.	.44 —	.....
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.53 —	.....
Pine oil, destructively distilled	gal.	.49 —	.53
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.35 —	.....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.40 —	.....
Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37 —	.....
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.26 —	.....
Fine tar, thin, sp. gr. 1.060-1.080	gal.	.30 —	.....
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.40 —	.....
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.19 —	.....
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08	gal.	.19 —	.....
Wood creosote, ref. f.o.b. Florida	gal.	.31 —	.....

Vegetable and Other Oils

China wood oil	lb.	.19½—	.20½
Cottonseed oil, crude	lb.	.17½—	.18
Linseed oil, raw, cars	gal.	1.28 —	.....
Peanut oil, crude	gal.	1.37 —	.....
Rosin oil, first run	gal.	.35 —	.....
Rosin oil, fourth run	gal.	.66 —	.....
Soya bean oil, Manchuria	lb.	.18 —	.18½
Turpentine, spirits	gal.	.49 —	.....

Miscellaneous Materials

Barytes, floated, white, foreign	ton	40.00 —	50.00
Barytes, floated, white, domestic	ton	30.00 —	36.00
Beeswax, white, pure	lb.	.56 —	.64
Casein	lb.	.22 —	.30
Chalk, light, precipitated, English	lb.	..... —	.....
Feldspar	ton	8.00 —	12.00
Fuller's earth, powdered	100 lb.	1.00 —	1.50
Ozokerite, crude, brown	lb.	.65 —	.75
Ozokerite, American, refined, white	lb.	.75 —	1.00
Red lead, dry, carloads	lb.	.10 —	.11¼
Rosin, 280 lb	bbl.	7.00 —	.....
Soapstone	ton	10.00 —	12.50
Talc, American, white	ton	15.00 —	22.00
White lead, dry	lb.	.09 —	.10

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal	
Chrome cement, Grecian	net ton	Nominal	
Clay brick, 1st quality fireclay	per 1000	50.00 —	55.00
Clay brick, second quality	per 1000	35.00 —	40.00
Magnesite, raw	ton	30.00 —	35.00
Magnesite, calcined	ton	35.00 —	36.00
Magnesite, Grecian, dead burned	net ton	85.00 —	90.00
Magnesia brick, Grecian, 9x4½x2½	net ton	135.00 —	140.00
Silica brick	per 1000	50.00 —	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y	ton	160.00 —	.....
Ferrocerium	lb.	18.00 —	.....
Ferrochromium, per lb. of Cr	lb.	.50 —	.....
Ferromanganese, domestic	ton	250.00 —	.....
Ferromanganese, English	ton	325.00 —	.....
Ferromolybdenum, per lb. of Mo	lb.	5.00 —	.....
Ferrosilicon, 75 per cent, f.o.b. N. Y	ton	..... —	.....
Ferrosilicon, 50 per cent, carloads, del., Pittsburgh	ton	165.00 —	175.00
Ferrosilicon, 50 per cent, contract	ton	100.00 —	175.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.35 —	2.45
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.00 —	.....
Ferrovanadium, f.o.b. works	lb.	4.00 —	5.00

Ores and Semi-finished Products

Antimony ore, per unit		1.60 —	1.75
Chrome ore, 48 per cent minimum, f.o.b. Cal., per unit	ton	1.55 —	1.65
Manganese ore, 48 per cent and over, per unit	ton	1.20 —	.....
Manganese ore, chemical	ton	80.00 —	100.00
Molybdenite, per lb. of MoS_2	lb.	2.15 —	.....
Tungsten, Scheelite, per unit of WO_3	ton	26.00 —	30.00
Tungsten, Wolframite, per unit of WO_3	ton	24.50 —	.....
Uranium oxide, 96%	lb.	3.25 —	3.60
Vanadium pentoxide, 99%	lb.	10.50 —	.....
Pyrites, foreign	unit	.16 —	.16¼
Pyrites, domestic	unit	.28 —	.30

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

THE ALL-STATE CHEMICAL MANUFACTURING COMPANY, New York. Nominal capital, $5,000. To engage in the manufacture of chemicals and allied products. Incorporators; W. Graveur, D. E. Hubener, and F. J. Nice, 525 West One Hundred and Sixty-ninth Street.

THE ALTREX COMPANY, Chicago, Ill. Capital, $10,000. To manufacture chemical preparations. Incorporators: Charles F. Brandel, James M. Rainey, and Walter Bashong, all of Chicago.

THE AMERICAN LEAD BURNING COMPANY, Inc., New York. Capital, $25,000. To engage in a general lead burning business, and manufacture chemical apparatus of various kinds. Incorporators: W. H. and E. D. Simonson, and G. W. Winans, 210 Parkside Avenue, Brooklyn.

THE ATLANTIC POTASH CORPORATION, Dover, Del. Capital, $1,000,000. To manufacture potash and chemical compounds.

BRANDON, HADGES & MCLAIN, New York. Capital, $20,000. To manufacture metallurgical supplies, graphite and carbon. Incorporators: A. C. Head, H. M. Eisenberg, and E. M. James, 2 Rector Street.

THE BROWN SAAL COMPANY, New York. Capital, $10,000. To engage in the manufacture of chemicals and allied products. Incorporators: W. C. Murphy, D. H. Cory, and J. E. Saal, 21 West Forty-sixth Street.

THE BURNS CARTRIDGE MANUFACTURING CORPORATION, Dover, Del. Capital, $500,000. To manufacture cartridges, etc.

THE CENTRAL SMELTING & REFINING WORKS, Inc., Bronx, N. Y. Capital, $50,000. To manufacture smelting and refining metals, etc. Incorporators: S. S. Paymer, J. J. Paymer, and N. Sacks, One Hundred and Thirty-seventh Street and Rider Avenue.

THE CHEMICAL CLAY PRODUCT COMPANY, Daisy, Tenn. Capital, $50,000. To manufacture chemical clay products. Incorporators: L. E., B. M. Hood, and G. S. Keeling.

THE SUPERIOR LEAD & ZINC COMPANY, Kingfisher, Okla. Capital, $150,000. To mine for lead and zinc. Incorporators: Luther V. Smith, S. Scott aand M. W. Hinch.

THE TENNESSEE BAUXITE COMPANY, Hixson, Tenn. Capital, $10,000. To develop bauxite mines estimated to contain about 500,000 tons of aluminum ore and install a drying and concentrating plant. Incorporators: C. W. Fisher, R. H. Hunt, and S. O. Bankson.

THE THOMPSON-WEIMAN COMPANY, Cartersville, Ga. Capital, $600,000. To mine for iron. W. J. Weinman is the principal incorporator.

THE TOPPER BROTHERS IRON COMPANY, Columbus, Ohio. Capital, $200,000. To operate a local iron works. Incorporators: L. L. Goldberg, S. Ornstein, Eugene Morgan, and I and M. Topper.

THE UNIONTOWN FOUNDRY COMPANY, Uniontown, Pa. Capital, $10,000. To operate a local plant. E. R. Floto is the principal incorporator.

THE UNITED STATES SANITARY PRODUCTS CORPORATION, Chicago, Ill. Capital, $100,000. To manufacture chemical compounds, etc.

THE UNITED STATES SMELTING FURNACE COMPANY, of Belleville, Ill., has been incorporated with capital of $50,000 to manufacture and sell smelting and melting furnaces and to smelt and melt ore and metals of all kinds.

THE VALVELESS FLUSH COMPANY, Wilmington, Del. Capital, $300,000. To manufacture flush tanks and devices, etc. Incorporators: F. L., M. E., and L. F. Mettier, Wilmington.

THE WEST COAST GLASS COMPANY, Los Angeles, Cal Capital, $100,000. To manufacture glassware of various kinds. Incorporators: H. R. Jones, Frank C. Ford, Arthur White, G. H. Bessemyer, and R. D. Tiffany

THE WHITNEY MACHINE COMPANY, Winchester, Mass. Capital, $100,000. To manufacture machinery. Incorporators: Arthur E. Whitney, Robert F. Whitney, and Walter C. Goddard, Winchester.

Construction and Operation

Alabama

BIRMINGHAM. — The Connors Steel Company, recently incorporated with a capital of $300,000, is planning to take over and operate the plant of the Woodlawn Rolling Mill, which has been operated by the president of the new company, George W. Connors. The plant will manufacture steel hoops, bands, bars, channels and other steel products.

TALLADEGA.—The Graphite Mills Company has recently taken over the plant and property of the Enterprise Graphite Company, and is planning for the construction of a large new mill on the Hurst property in Clay County to provide for increased capacity. The entire plant of the company will also be removed to this location.

Arizona

BISBEE.—The Copper Queen Consolidated Company is planning for the construction of a large new concentration mill near Warren for the handling of the sulphide taken from Sacramento Hill. At this point there is an immense deposit of the sulphide and the company has started steam shovel stripping.

JEROME.—The United Verde Extension Mining Company is making rapid progress in the construction of a new 1600-ton smelter, the entire works being estimated to cost $3,000,000. The company has also commenced construction of a 12,000-foot tunnel in the Verde Valley for haulage from its mines.

KELVIN.—The Ray-Hercules Copper Company, Ray, is rushing to completion the erection of a large new local copper mill, which will cost, when completed, about $2,000,000.

BISBEE.—The Superior & Pittsburgh Mining Company is planning for the construction of a large new mill at its local properties for the handling of silver-lead ores.

TUCSON.—Roos & Tovote have recently acquired the smelter at Socorro, New Mexico, and are planning for the immediate dismantlement of the plant and shipment to its local works, where it will be utilized as a custom plant, with daily capacity of from 250 to 300 tons of ore.

YUMA.—Operation has been inaugurated in the new concentration mill recently completed at the Red Cloud mine, about forty miles north of Yuma. The mill is of 300 tons capacity, and is equipped with Hendy crusher, Eggleston ball-mill, and three Stebbins dry-concentrating tables. Cris Engle is superintendent.

YUMA.—The Carmelita Mining & Milling Company has commenced the installation of considerable new equipment at its local properties, including hammer-drills, gasoline hoist, Ritz air-compressor, ball-pulverizer, three concentrating tables, and flotation process. The company is planning for extensive development of the seventeen claims which comprise its property. J. A. Marx is superintendent.

Arkansas

KINGDON SPRINGS.—E. N. Stanfield, Oklahoma City, Okla., has recently acquired the Monkey Hill zinc mines, and is planning for extensive development.

California

BAY POINT.—The Pacific Electro Metals Company has contracted with the Great Western Power Company, San Francisco, for supplying power for the operation of the first unit of its new chemical plant now in course of construction. About 4,000 kw. will be necessary for the initial unit.

LOS ANGELES.—The American Can Company is planning for the early construction of a large new plant for the manufacture of cans. The project is estimated to cost $1,000,000, and when completed and in operation the new works will have a capacity of about 3,000,000 cans daily, and will give employment to about 1500 hands.

LOS ANGELES.—The Union Oil Company has commenced the construction of the first unit of its new refinery at Los Angeles Harbor for the manufacture of lubricating oils, gasoline, kerosene, and other petroleum products. When completed the plant will cost about $2,000,000.

LOS ANGELES.—The Warman Steel Casting Company, Douglas Building, manufacturer of electric and crucible steel castings, has awarded a contract for the construction of a new 100-foot addition to its plant. The company is planning to double the capacity of its plant at Huntington Park.

INGOT.—The Afterthought Lead & Zinc Mining Company has recently completed the construction of a large new oil flotation plant, and operations will be inaugurated at an early date. The ore is subjected to two flotations—the first removes the sulphide from the gangue, after which this concentrate is roasted and again floated, when the zinc is separated from the copper. The company is planning for the erection of twenty cottages at the mine for the convenience of its employees. George L. Porter is president; J. T. Robertson is general manager.

KESWICK.—The Mountain Copper Company is planning to double the capacity of its oil-flotation plant at Minnesota station, near Keswick. The enlarged plant will have a capacity of about 1000 tons of ore daily.

OAKLAND.—The Occidental Chemical Company, which is a reorganization of the kelp reduction business of the California Chemical Company, Summerland, is planning for the establishment of a large new plant.

TAFT.—The Richfield Oil Company, which recently acquired the plant of the Phoenix Refinery Company, Bakersfield, is said to be considering the construction of a large new local compressor plant for the extraction of gasoline from high gravity oil.

Colorado

CLIMAX — The Molybdenum Products Company is making rapid progress in the construction of a new mill for the handling of molybdenum taken from its holdings. The company is also planning for more extensive development.

CLIMAX.—The new concentration plant of the American Metal Company, Summit County, for the handling of molybdenum, is rapidly nearing completion, and extensive development work is planned by the company. A satisfactory process of treatment has been perfected, and it is anticipated that a large tonnage of ore will be concentrated during the present year.

DENVER.—Fire recently destroyed a portion of the plant of the Chemical Products Company, Louisiana and South Jason Streets. The destroyed building was used exclusively for the production of vanadium for the British Government, and will be immediately rebuilt. The total loss is estimated at $50,000. Lafayette M. Hughes is president.

PUEBLO.—Plans have been completed and construction will be commenced at once on the new local plant of the Norcross Chemical Company, to be located near Stone City. The buildings include tank houses, acid towers, boiler rooms, and other structures, and will be used for the manufacture of acids, chemicals, and munitions. W. J. Cooper is construction superintendent.

Connecticut

NEW HAVEN. — The International Leather & Belting Company, Middletown Avenue, has had final plans prepared for the initial unit of its new plant, which will be one-story brick and steel, about 50 x 150 feet. The entire project is estimated to cost about $200,000. The company has recently acquired additional property in Middletown Avenue for extensions.

Delaware

WILMINGTON.—The E. I. duPont deNemours Company has recently commenced the construction of its proposed new shell-loading plant at Williamsburg, Va., to execute orders for the Government. The entire project is estimated to cost about $8,000,000.

WILMINGTON.—Fire recently destroyed the punch shop at the plant of the Pusey & Jones Shipbuilding Company, with loss estimated at about $75,000.

Illinois

CHICAGO.—The Chicago Bearing Metal Company, 2234 West Forty-third Street, is making rapid progress in the construction of a new one-story plant at 2216 West Forty-third Street. The structure will be about 100 x 225 feet, and is estimated to cost $15,000.

CHICAGO.—The Universal Concrete Products Company, 122 South Michigan Avenue, has commenced the construction of a new one-story plant, about 80 x 450 feet, on Port Washington Road.

CHICAGO.—The Railway Mine & Supply Company, 332 South Michigan Avenue, has commenced the construction of a new plant at Kincaid to consist of a one-story blacksmith shop, about 65 x 100 feet; one-story foundry, 60 x 375 feet, and one-story assembling works. The new plant will cost about $75,000.

SPRINGFIELD.—The United States Industrial Alcohol Company, New York, manufacturer of distilled spirits for industrial and medical purposes, and which operates a large plant in Peoria, has filed articles of incorporation with a capital of $18,000,000 to operate in Illinois. Of this capital $388,000 will be employed in the state.

Indiana

INDIANAPOLIS.—Fire, on January 23, completely destroyed the plant of the Stewart-Carey Glass Company, with loss estimated at about $150,000.

Iowa

DES MOINES.—Harry Cohen of the Cohen Brothers Iron & Metal Works, 307 East Third Street, and associates, are now organizing a large new corporation to have a capitalization of $1,000,000, for the erection of a large roller mill on the site of the old starch works, East Des Moines. It is said that the new plant will give employment to about 5000 hands when running to capacity.

Kansas

JOPLIN.—The Dick Turpin Concentrating Company, with concentrating plant situated on the Riseling land, just southwest of Joplin, has been acquired by the American Metal Company, and the concentrating plant will be removed to the recently acquired leases west of Baxter Springs. The Dick Turpin mill was erected by D. W. Sparks and associates about two years ago.

TOPEKA.—Fire recently destroyed a portion of the plant of the Pioneer Waste Paper Company, Ninth and Adams Streets, with loss estimated at about $10,000.

CHANUTE.—The City officials have awarded contracts for extensions and improvements in the municipal power plant to cost about $25,000. G. G. Wood is city clerk.

Kentucky

PADUCAH.—T. N. Hazelip and E. C. Phelps have leased extensive fluorspar properties in Crittenden County, Kentucky, and Hardin County, Illinois, and are planning for development of the mines.

Louisiana

SHREVEPORT.—The Marine Oil & Refining Company is said to be considering the immediate construction of a large new oil refinery. It is anticipated that the new plant will be ready for operation by the middle of the summer.

Maryland

BALTIMORE.—The United States Industrial Chemical Company has had plans prepared for the construction of a new one-story machine shop, about 80 x 100 feet, at its Curtis Bay works. The new addition will cost $50,000. The company is also planning for a new one-story copper shop to cost $50,000.

BALTIMORE.—The Poole Engineering & Machine Company has recently acquired additional property at its plant for extensions. Additions to the plant now under way are estimated to cost $500,000. The new plant now in course of construction will be used for manufacturing ordnance for the United States Government, and forgings for large guns will be the product of the foundries.

BALTIMORE. — The Bartlett-Hayward Company has acquired a tract of about 40 acres as a site for the construction of a large new plant for the manufacture of munitions. Contract for the new works has been awarded to Morrow Brothers, Fidelity Building, Baltimore.

EDGEWOOD.—The United States Government is having plans prepared for the construction of forty-eight buildings for a new shell-filling station for the Ordnance Department, the entire plant being estimated to cost $4,000,000. The works will include mixing warehouses, supply pumps, chemical and physiological laboratories, etc. The Mellon-Stuart Company, Pittsburgh, Pa., is the contractor.

Massachusetts

ANDOVER.—Fire, on January 31, caused by an explosion, destroyed the plant of the Beaver Chemical Manufacturing Company, which was engaged on important work for the Government. The total loss is estimated at about $100,000.

SPRINGFIELD.—The Springfield Gas Light Company is planning for the installation of machinery for the recovery of toluol for Government use in producing trinitrotoluol for explosives. It is anticipated that approximately 30,000 gallons will be obtained annually. Charles H. Tenney is president.

WOBURN.—Fire, on January 30, destroyed a portion of the plant of the Merrimac Chemical Company, with loss estimated at about $10,000. It is said the damaged section will be immediately rebuilt.

Michigan

MARQUETTE.—Fire, on January 29, destroyed a portion of the plant of the Pioneer Iron Furnace Company, controlled by the Cleveland Bluffs Iron Company, of Cleveland, Ohio. The alcohol refining plant, primary building, and several condensers were completely destroyed, with loss estimated at approximately $150,000. This plant was one of the largest producing alcohol and other chemicals for the Government.

Minnesota

BRAINERD.—The Northwest Paper Company is said to be considering the construction of additions to its plant to double the present capacity.

Missouri

CARTHAGE.—Favorable progress is being made by the Pleasant Valley Mining Company, about three miles southwest of Carthage, on the construction of a new concentrating plant. The concentrate at this lease is particularly satisfactory, being lead free, less than 1 per cent in iron, and usually showing about 62 per cent metallic zinc.

KANSAS CITY.—The Winslow Manufacturing Company, manufacturer of tractors, has recently filed plans and awarded a contract for the construction of a new one-story plant, about 50 x 120 feet. The structure is estimated to cost $40,000.

WACO.—Fire recently destroyed a portion of the plant of the Putte-Kansas Mining Company, Jasper County, with loss estimated at $75,000. A section of the new 400-ton concentrating plant, recently completed, was also damaged. The mill will be immediately rebuilt.

Nevada

RENO.—The Consolidated Mayflower Mines Company has been making extensive developments for the production of milling and shipping ore on 200 and 300-foot levels at its Mayflower mine in Nye County, and 1400 feet northwest of the shaft a promising vein has been uncovered near the surface and opened to a depth of 35 feet. The vein consists of excellent milling ore, with portions carrying a high gold content. The company will make extensive alterations and improvements at its mill. W. J. Tobin is president.

RAND.—The Nevada Rand Mining Company, located near Rand, is planning for the construction of a large new concentration mill.

New Jersey

MAYS LANDING.—The Bethlehem Steel Company is planning for the immediate construction of a large new local shell loading plant for the United States Government on its property along the Egg Harbor River, and it is anticipated that the new works will be ready for operation in about three months. About 2000 hands will be employed.

DOVER.—The International High Speed Steel Company, one of the comparatively new industries in this section, is now operating its works at full capacity for the manufacture of solid and hollow rock drill steel. The plant is located about two miles from the city, fronting on the tracks of the Lackawanna Railroad.

NEWARK.—The Balbach Smelting & Refining Company, 580 Market Street, has taken out a building permit for the construction of a new brick and steel addition to its plant, about 45 x 64 feet. The company will also make alterations and improvements in its casting and copper furnace works on Ferguson Street.

NEWARK. — The Butterworth-Judson Corporation, Avenue R, manufacturer of chemicals, will build a new one-story engine plant, about 57 x 110 feet, at its plant on Roanoke Avenue. The structure will cost about $25,000.

NEWARK. — The Northern Leather Works & Produce Company, 377 Broadway, New York, is having plans prepared for the construction of the first unit of its proposed new local plant on Backus Street. The structure will be three-story and basement, about 40 x 130 feet.

NEWARK.—The Heller & Merz Company, manufacturer of chemicals, dyes, etc., has filed authorization papers to operate in New York with a capital of $500,000. P. Schnorrenberger, 503 Hudson Street, New York, has been appointed representative.

PAULSBORO.—Construction has been completed on the new plant of the I. P. Thomas Phosphate Company, and it is planned to inaugurate operations at an early date. The structure was erected at a cost of $50,000.

ELIZABETH.—Fire recently damaged a portion of the plant of the Kalbfleisch Chemical Company at Third Avenue and Baltic Street. The destroyed section will be immediately rebuilt.

New York

NEW YORK.—The United States Industrial Alcohol Company, 27 William Street, has recently acquired the distillery of Clarke Brothers & Company, Peoria, Ill., and will make alterations and improvements for the manufacture of chemicals.

LONG ISLAND CITY.—The Central Smelting & Refining Company is having plans prepared for the construction of a new one and one-half-story plant, about 75 x 180 feet, at Borden Avenue, Hayward and Third Streets.

COLONIE.—The Colonie Fibre Company has awarded a contract to Lewis & Bennett, Troy, for alterations and improvements at the plant formerly occupied by Crampton & Beldon. As soon as this work is completed machinery will be installed for the manufacture of woolen fibre.

SYRACUSE.—Fire, on January 27, destroyed a portion of the plant of the Syracuse Rendering Company, with loss estimated at $100,000.

MECHANICSVILLE.—The United States Government is planning for the immediate construction of a large new chemical plant to utilize the by-products of the paper manufacturing plants of the West Virginia Pulp & Paper Company. The works will specialize in the production of acetone, which is used to mix with varnish for coating aeroplane wings.

Ohio

CANTON.—Fire recently destroyed the plant of the Miller Pasteurizing Machinery Company, manufacturer of pasteurizing and other dairy equipment, with loss estimated at $200,000.

CARTHAGE.—Three of the five main units of the Hess Spring & Axle Company plant, 124 West Sixty-sixth Street, were destroyed by fire on January 23, with loss estimated at about $100,000.

LEETONIA.—The Fabricated Steel Products Company, recently organized with a capital of $150,000, has acquired the plant of the Leetonia Boiler Company, and is planning for the installation of new equipment, including punches, spitting shears and riveters, to provide for increased capacity. The company is engaged in the manufacture of boilers, tanks, wireless towers, and other plate material work for the Government.

LIMA.—Fire on January 29 destroyed a portion of the plant of the Townsend Oil Products Company, with loss estimated at $20,000.

LORAIN.—The J. C. Cromwell Steel Company, manufacturer of steel billets and other steel products, is planning for the construction of five new blast furnaces at its plant to provide for increased capacity.

TOLEDO.—The Buckeye Paint & Varnish Company, manufacturer of paints, varnishes, etc., is planning for the early construction of a large new three-story addition to its plant, to provide for increased capacity.

Oklahoma

ARDMORE.—The Chickasha Refining Company is making rapid progress in the construction of a large new refinery to have a daily capacity of about 3000 barrels, and it is anticipated to inaugurate operations at an early date.

MIAMI.—The Ken-Tex Company, recently incorporated with a capital of $200,000 to mine for lead and zinc, is planning for the construction of a large new mill.

OKLAHOMA CITY.—The Medical Mining Company, recently incorporated with a capital of $200,000, is planning for the immediate development of about 40 acres of lead and zinc lands and the erection of a 250-ton mill.

Oregon

GOLD HILL.—O. C. Runnalls, Seattle, Wash., and associates, who recently acquired the Utah and Bertleson groups of cinnabar mines, twelve miles north of Gold Hill, are planning to equip the properties with a mercury-reduction plant of 100 to 200 tons capacity.

TAKILMA.—The Atlantic Ore & Alloys Company, Philadelphia, Pa., is planning for the construction of a new plant at the Golconda chrome mine, to have a capacity of about 100 tons daily. Development at these properties has been suspended for the past few months. R. J. Rowan is manager.

Pennsylvania

ALLENTOWN.—Fire, on January 16, damaged the No. 7 tempering plant of the Saucon mill of the Bethlehem Steel Company, used for the manufacture of gun forgings, with loss estimated at $10,000. It is said the destroyed section will be immediately rebuilt.

PHILADELPHIA. — The Philadelphia Paper Manufacturing Company is planning for extensive alterations and improvements at its plant to provide for increased capacity. The work is estimated to cost $25,000.

PHILADELPHIA. — Fire recently destroyed a portion of the glass manufacturing plant of H. Perlistein, 510-18 South Randolph Street, with loss estimated at $50,000.

PITTSBURGH.—The Carbon Steel Company has taken out a building permit for the construction of a large new coal gas producing plant on Putney Way, between Thirty-second and Thirty-third Streets. The new works will be of steel and concrete construction, about 35x185 feet, and are estimated to cost $225,000.

PITTSBURGH.—The Eagle Paint & Varnish Company, 225 Galveston Avenue, manufacturer of paints, varnishes, etc., has recently completed alterations and improvements at its plant to provide for increased capacity.

TYRONE.—The United States Government is planning for the construction of a large new plant on local property owned by the West Virginia Pulp & Paper Company, to be devoted to the manufacture of alcohol and other chemicals from the liquor in which wood is prepared. The new plant will give employment to about 250 hands. The works will be taken over and operated by the West Virginia company as soon as the Government desires.

WILLIAMSPORT.—Fire recently destroyed a portion of the plant of the National Foundry & Manufacturing Company, which was engaged on some important work for the Government. The loss is estimated at about $40,000, including the destruction of some valuable patterns. The destroyed section will be immediately rebuilt.

Rhode Island

PROVIDENCE.—Fire recently destroyed a section of the plant of the Providence Dye Works, South Angell and East River Streets, manufacturers of dye-stuffs, with loss estimated at about $35,000.

Tennessee

CHATTANOOGA.—The Tennessee Bauxite Company, recently organized, has acquired the lease of a large deposit of bauxite which has recently been operated up near Hixon, and is planning for immediate development. The mine is located about fifteen miles northeast of Chattanooga, near the Tennessee River.

COLLINWOOD.—The Tennessee Iron & Railroad Company is planning for the construction of a large new plant to be devoted to the manufacture of wood alcohol, acetic acid and acetone, with charcoal as a by-product. The plant will be owned by the Government, which will utilize all the product with the exception of the charcoal, which the Tennessee corporation will use for fuel in its iron furnace now under construction. The project will cost about $800,000.

KINGSPORT.—The Kingsport Wood Reduction Company, recently incorporated by Chicago capitalists, is planning for the construction of a large local plant for the manufacture of wood distillates. Estimated cost of the work is $700,000.

MT. PLEASANT.—The International Agricultural Corporation is planning for the immediate reconstruction of its phosphate plant recently destroyed at a loss of about $15,000.

Texas

RUSK.—T. L. Featherstone & Company, who recently acquired the furnace and pipe foundry from the State penitentiary, are making extensive alterations and improvements, and are planning to inaugurate operations early in the spring, the furnace to have a capacity of about 100 tons of pig iron daily, and the pipe foundry, about 50 tons of water pipe daily.

West Virginia

MORGANTOWN.—The Star Glass Company, near Star City, is planning for the immediate reconstruction of its plant recently destroyed by fire with loss estimated at $100,000.

Washington

HOQUIAM. — R. Thomas, manufacturer of paper and pulp, has made announcement that plans are under consideration for the construction of a large new local plant for the manufacture of wood pulp and paper, to have an initial capacity of about 100 tons of pulp daily.

SPOKANE.—The Coeur d'Alene Antimony Mining Company, is planning for the establishment of a large electrolytic antimony plant for the handling of ore taken from the company's properties on Pine Creek, Idaho. H. E. Jolly is president.

Wisconsin

MILWAUKEE.—The Hummel & Downing Company, Thomas Street and North Cambridge Avenue, manufacturer of box-board and fibre-board, has completed the construction of its new 140-inch paper mill, and operations have been inaugurated. The new plant was erected at a cost of about $800,000.

RACINE.—Fire recently destroyed the main building of the Belle City Malleable Iron Company, with loss estimated at about $75,000.

Wyoming

RIVERTON.—The Riverton-Wyoming Refining Company is planning for the construction of a large new oil refinery to cost about $127,000. Plans for the plant, which will have a capacity of 3,000 barrels, are being prepared.

Alaska

TREADWELL.—The Alaska Treadwell Company is planning for the immediate installation of new equipment at the Treadwell molybdenite mines at Shakan for early development work. It is said a new concentrating plant will also be erected.

Canada

SUDBURY.—The British American Nickel Corporation is making rapid progress in the construction of a new electrically-operated smelting refinery, which will have a capacity of 2,500 tons of ore daily and a nickel production of 20,000,000 pounds per annum.

PORT COLBORNE, ONTARIO.—The International Nickel Company has commenced the erection of a large new refinery which is estimated to cost $4,000,000, to have an initial capacity of 15,000,000 pounds per year. It is anticipated to inaugurate operations within the next few months.

Trade Notes

HESS & SON, Philadelphia, Pa., manufacturers of Tinol paste solder, wire solder, alcohol torches, and flux, and epicassit, have removed to 1302-4 Filbert Street, where increased manufacturing facilities are available.

THE DRIVER-HARRIS COMPANY, Harrison, N. J., announces that it is now prepared to supply 99 per cent cold-rolled pure nickel sheets. On Jan. 1, there was distributed to all employees, having been with the company at least six months on that date, a life insurance policy to an amount of $500. It is the intention of the company to make further distribution of these policies as other employees reach the six months service period. The fourth annual dinner of the company was held at the Down Town Club, Newark, on Friday evening, Dec. 28, and was a very enjoyable affair. The entire office staff and the heads of the factory departments, and veteran employees of the company were invited. The number participating was approximately 146 persons. After dinner was served and some short speeches were heard, the evening was devoted to dancing and recreation.

DYESTUFFS IN THE TRADE OF SIAM.—Aniline dyes are not manufactured in Siam, according to a consular report, and the native vegetable dyes with which the Siamese in the past produced the enduring, bright, and beautiful tints on their homemade garments are now being displaced largely by imported dyestuffs. Dyeing in black, however, is still an important industry in Bangkok. Considerable quantities of silk piece goods are sent from China each year to be dyed in the juice of the green berries and leaves of the native tree "makua" (*Diospyros mollis*). This imparts to the fabric a bright jet-black color which will stand washing. Stuffs dyed in this preparation are enhanced in value. Siam's imports of dyes of all sorts for the years ended March 31, 1914, 1915, 1916, and 1917 were: For fiscal year 1914, 563,090 pounds valued at $70,936; for 1915, 459,033 pounds valued at $49,590; for 1916, 730,876 pounds valued at $50,166; and for 1917, 974,845 pounds valued at $87,360. The imports for the fiscal year 1917 consisted of 102,418 pounds of aniline colors valued at $34,126; 805,252 pounds of indigo valued at $40,197; and 67,185 pounds of all other dyes valued at $13,037. Of the aniline imports for last year 88,102 pounds were shipped from Holland, and 11,636 pounds from the United Kingdom. Nearly all shipments during 1916-17 were made from oriental ports. There were no exports of dyes from the United States to Siam during that period.

THE PRATT ENGINEERING & MACHINE CO. of Atlanta, Ga., has changed its New York office from 61 Broadway to 25 West Forty-fourth Street.

Manufacturers' Catalogs

THE TITANIUM BRONZE CO., INC., 504 Marine Bank Bldg., Buffalo, N. Y., has issued a booklet describing its method of manufacturing phosphor bronze castings.

BACHARACH INDUSTRIAL INSTRUMENT CO., Pittsburgh, Pa., has issued a pamphlet describing "hydro" gas meters.

LINK BELT CO., Chicago, Ill., has issued a booklet entitled "The Ideal Drive for Rubber Mill Machinery."

KAESTNER & HECHT CO., Chicago, Ill., have issued an attractive catalog describing their line of paint machinery, including mixers, mills, tanks and special apparatus.

RUBBER INSULATED METALS CORPORATION, Plainfield, N. J., has issued a pamphlet describing "Rimco" rubber insulated pliers.

PYROLECTRIC INTRUMENT CO., Trenton, N. J., has issued circular No. 9, describing the Northrup millivolter for accurate e.m.f. measurements up to one volt.

New Publications

NEW GEOLOGICAL SURVEY REPORTS: Fluorspar and Cryolite in 1916. By Ernest F. Burchard; Gold, Silver, Copper, Lead and Zinc in California and Oregon in 1916. By Charles G. Yale; Gold, Silver, Copper, Lead and Zinc in Montana in 1916. By V. C. Heikes; Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1916. By Charles W. Henderson; Gold, Silver, Copper, Lead and Zinc in the Eastern States in 1916. By James M. Hill; Gold, Silver, Copper, Lead and Zinc in Arizona in 1916. By V. C. Heikes; Mica in 1916. By Waldemar T. Schaller; Sand and Gravel in 1916. By R. W. Stone; Zirconium and Rare-Earth Minerals in 1916. By Waldemar T. Schaller.

NEW BUREAU OF MINES TECHNICAL PAPERS: No. 158, Compressibility of Natural Gas and Its Constituents with Analyses of Natural Gas from 31 Cities in the United States. By G. A. Burrell and I. W. Robertson. No. 155, Gypsum Products, Their Preparation and Uses. By R. W. Stone. No. 174. Suggestions for the Safe Operation of Gasoline Engines in Mines. By R. H. Kudlich and Edwin Higgins. No. 133 Directions for Sampling Coal for Shipment or Delivery By George S. Pope. Methods for Increasing the Recovery from Oil Sand. By J. O. Lewis. Bulletin 148 issued by the Department of the Interior, Washington, D. C.